

**Regional Wastewater
Services Plan**

**RWSP Water
Quality Report**

March 2004



King County

Department of
Natural Resources and Parks

Wastewater Treatment Division

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Executive Summary

This report describes the efforts of King County's Department of Natural Resources and Parks (DNRP) in 2003 to protect and preserve water quality in Puget Sound and the major lakes and rivers in the county. In particular, this report is concerned with those waters that benefit from, or could be impacted by, the operations of King County's wastewater treatment and conveyance system; namely, management of wastewater, discharges of treated wastewater, sanitary sewer overflows (untreated wastewater), and combined sewer overflows (untreated wastewater combined with stormwater runoff).

This report is required by King County Ordinance 13680, which adopted the Regional Wastewater Services Plan (RWSP)—a \$1.8 billion¹ capital improvement program to provide wastewater capacity for this region for the next 30 years and beyond. Ordinance 13680 identified the need for an annual water quality report to “ensure that the RWSP reflects current conditions and addresses water pollution abatement, water quality monitoring results, water conservation and water reclamation, Endangered Species Act compliance, septic system conversions to the regional sewer system, biosolids management, wastewater public health problems, and compliance with other agency regulations and agreements.”

This Executive Summary provides an overview of the information provided in this report, beginning with a summary of the state of waters in King County and continuing with a description of the County's programs to manage water quality and monitor its waters.

State of the Waters

Three major groups of waters are described in this report: the major lakes, including Lake Washington, Lake Sammamish, and Lake Union; the rivers and streams, including the Cedar River, the Sammamish River, and the Green and Duwamish Rivers; and the marine waters of Puget Sound. These waters are shown in Figure 1 (in Chapter 1) and their status is summarized below.

Major Lakes

Water quality in the major lakes, as described by their biological productivity, has ranged between moderate to exceptionally good during the last several years. Historically, excess phosphorous loading was a problem in both Lake Washington and Lake Sammamish, resulting in nuisance algal blooms in the summer. Lake Washington had good water quality in 2003, with good water clarity and low concentrations of algae. Water quality was good in Lake Sammamish in 2003 with good water clarity, low concentrations of algae, and moderate concentrations of phosphorous. Since 1998, phosphorous concentrations in Lake Sammamish have been well below the goal of 22 ug/L (mean annual volume weighted total phosphorous) as defined in the 1989 Lake Sammamish Management Plan. However, Lakes Washington and Sammamish remain vulnerable to water quality degradation by urbanization and land use

¹ In 2003 dollars.

activities such as construction, development, forestry, and farming. Lake Union's water quality was moderate in 2003 and has fluctuated between moderate and good since 1994.

Rivers and Streams

Water quality in the Cedar River is typically very high. The Cedar River was listed on the Washington State Department of Ecology's 1998 303(d) list² for exceeding the fecal coliform standard, as do many other state waters. Much of the Cedar River watershed is forested, which is the major contributor to the continued high water quality in the river. Diversion of flows from the river for drinking water is a major issue for the Cedar River.

The Sammamish River is listed on the 1998 303(d) list for exceeding standards for temperature, dissolved oxygen, pH, and fecal coliform. High river temperatures typically occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature and low dissolved oxygen are considered serious water quality problem limiting salmonid survival in the river.

Water quality in the Green River and its tributaries varies widely depending on location in the watershed, level of urbanization, and human activities. Numerous streams throughout the Green-Duwamish watershed are listed on the 303(d) list, including portions of the Duwamish River and lower Green River. Low dissolved oxygen, high temperature, and high fecal coliform bacteria levels are concerns in the Green River watershed, and there has been a trend toward increasing water temperatures in tributaries in the urbanized part of the watershed. Sediment contamination is a significant focus of attention in the Lower Duwamish River.

Puget Sound

The marine waters of Puget Sound within King County are in very good condition overall and do not show evidence of persistent bacterial, nutrient, or toxicant pollution. Offshore waters have consistently shown high levels of dissolved oxygen and low fecal coliform bacteria over the last several years. There were some pollution problems in the nearshore environment, however, with localized areas failing Water Quality Standards for fecal coliform bacteria—particularly in areas near freshwater sources or in areas of poor tidal flushing. Another localized problem is sediment contamination, which is evident primarily in Elliott Bay.

Water Quality Management Programs

King County has many programs in place that protect and preserve water quality. The wastewater treatment system collects wastewater from 32 cities and sewer districts serving approximately 1.4 million residents and conveys it to a local plant on Vashon Island, and to two regional treatment plants: the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton. On average, these plants provide secondary treatment for over 183 million gallons of wastewater each day. The quality of treated effluent from these plants

² The 303(d) list identifies water bodies that do not meet State Water Quality Standards.

remained high in 2003 with effluent values typically much higher in quality than what is required by wastewater discharge permits.

King County also has a program to reduce the amount of combined sewer overflows (CSOs), with two large CSO projects under way at Denny Way and Henderson/Martin Luther King Jr. Way. As part of the RWSP, the County has committed to controlling all its CSO discharge locations to no more than one untreated discharge per year by 2030, as required by Washington State regulation. In addition, two source control programs are working to prevent pollutants from even reaching our treatment plants and the environment—the Industrial Waste Program and the Local Hazardous Waste Management Program. For example, last year the Industrial Waste Program, which regulates industrial wastewater discharges, collected 2,170 samples and found 142 violations of discharge regulations. All violations were followed up with some form of enforcement action. The County also recovers its resources where possible, recycling 100 percent of its biosolids from the wastewater treatment process, implementing a program that provides reclaimed water for use in treatment plant operations and for customers in the service area, and recovering methane (digester gas) for use in running plant operations. This year marks the beginning of an innovative effort - fuel cell demonstration, which will use 20 percent of the plant's gas production and will produce 1 MW of electricity. If successful the County will continue its operation to "recycle" a byproduct of wastewater management into electricity.

Monitoring the Health of King County Waters

To protect public health and its significant investment in water quality improvements, King County regularly monitors its major lakes, beaches, streams, marine waters, and wastewater effluent. The major lakes monitoring program collects samples from 5 sites in Lake Union, 13 sites in Lake Washington, and 7 sites in Lake Sammamish. Sampled parameters include temperature, dissolved oxygen, pH, conductivity, clarity (Secchi Transparency), phosphorus, nitrogen, and fecal coliform bacteria. In addition, the County installed five robotic buoys to collect water quality data from Lake Washington and Lake Sammamish. The buoys continuously measure temperature, pH, dissolved oxygen, and chlorophyll-*a*.

The swimming beach monitoring program assesses beaches on Lake Sammamish, Lake Washington, and Green Lake every summer. This effort, ongoing since 1996, tests for bacteria to determine if there are risks to human health.

The stream monitoring program targets locations in streams and rivers where they cross sewer trunk lines or if they are considered a potential source of pollutant loading to a major water body. The long-term program has sampled at 54 sites on 4 rivers and 28 streams for many years.

King County's marine monitoring program routinely evaluates nutrient, bacteria, and dissolved oxygen levels in the waters of the main basin of Puget Sound. The program also includes monitoring of sediment quality near outfalls and at ambient locations. The goals of the ambient monitoring program are to better understand regional water quality and to provide data needed to identify trends that might show impacts from long-term cumulative pollution.

In addition, the County conducts special intensive investigations of water quality to support specific decision-making. Currently two watershed studies are under way to understand water quality issues and needs, to project future growth impacts in County watersheds, and to identify any needed improvements to salmon habitat. Several studies are underway to support decision-making, siting and construction of wastewater management facilities.

King County regularly monitors its wastewater effluent using process laboratories at both of its regional treatment plants and the environmental laboratory in Seattle.

2003 Results

Management and monitoring program performance in 2003 indicates that County efforts continue to make a significant contribution to protecting regional water quality and protecting public health. No needs were identified that are not already being addressed, and the wastewater system is achieving its purposes. Continuing vigilance by agencies like King County is recommended though, as the pressures of urbanization on water quality are increasing. King County residents will then continue to enjoy the excellent water quality that they value and expect.

Chapter 1

Background

In 1911, the City of Seattle completed the Fort Lawton Tunnel to discharge untreated wastewater flows off West Point (what is now Discovery Park) into Puget Sound. Early wastewater systems, which were the beginning of the current combined sewerage system in the City of Seattle, were built to collect wastewater from homes and businesses and stormwater runoff from streets.

By the 1950s, more than 25 small wastewater treatment plants were operating in the Seattle metropolitan area. Treatment plants did not serve all communities. Untreated wastewater entered Lake Washington, Lake Sammamish, Elliott Bay, the Duwamish River, the Lake Washington Ship Canal, and Puget Sound. For example, about 40 million gallons of untreated wastewater was discharged off of Discovery Park each day.

The degradation of water quality in Lake Washington resulted in beach closures, and there was concern about the future of other local waters. A grassroots citizens committee was formed that successfully sponsored state legislation allowing formation of a municipal corporation to manage the wastewater pollution problem for the Seattle metropolitan area. As a result, the Municipality of Metropolitan Seattle (Metro) was formed in 1958 to assume responsibility for cleaning up Lake Washington and establishing a regional wastewater system.

Metro developed the *Comprehensive Sewerage Plan* that became the guiding planning document for wastewater treatment services in the Lake Washington drainage basin for the next 35 years. Under that plan, Metro built regional treatment plants, closed small plants, constructed major trunk lines and the pump station needed to move the wastewater to the new plants, and eliminated 46 untreated wastewater discharge points into Lake Washington and Lake Sammamish. The plan was amended periodically; with the *1999 Regional Wastewater Services Plan* (RWSP) being the most recent significant amendment.

By the 1960s, Lake Washington's water quality had dramatically improved. The King County area became known as a national model of citizen action in cleaning up the environment. Metropolitan King County assumed Metro's functions in 1994. With the combined King County and Metro resources and expertise, the County became a regional provider of water quality protection services.

In addition to providing wastewater management services, King County performs many other activities to protect and improve water quality. These activities include monitoring water quality in lakes and streams, educating the public about water quality issues, and providing grant funds for local water quality projects. Water quality sampling and monitoring efforts began in 1962 to track cleanup progress in Lake Washington and to measure the impacts of diverting wastewater effluent from the lake to deep-water outfalls in Puget Sound. Monitoring programs and scientific studies have since remained a key element, informing County decisions on wastewater service and water quality management activities, as well as evaluating the effectiveness of those actions.

Purpose of this Report

The RWSP, King County's most recent comprehensive plan amendment, is a \$1.8 billion (in 2003 dollars) capital improvement program to provide wastewater capacity for this region for the next 30 years and beyond. The plan includes the following elements:

- Siting and construction of a new regional treatment plant in the north County service area
- Construction of many new conveyance lines and pump stations
- Implementation of 21 projects to complete combined sewer overflow (CSO) control
- Implementation of programs to investigate control of inflow and infiltration of clean water into the County system, water reuse, and technologies to manage treatment plant solids

King County recognized that the RWSP needed to be flexible and adaptable to changing conditions and needs. In the Ordinance 13680 (1999) adopting the RWSP, the County required the development of an annual water quality report. The purpose of the report, as stated in the ordinance is as follows:

[To] ensure that the RWSP reflects current conditions and addresses water pollution abatement, water quality monitoring results, water conservation and water reclamation, Endangered Species Act compliance, septic system conversions to the regional sewer system, biosolids management, wastewater public health problems, and compliance with other agency regulations and agreements.

This *2004 RWSP Water Quality Report* meets this requirement. This report, along with the 2001, 2002 and 2003 water quality reports, informs the comprehensive plan review—the *2004 RWSP Update*—that accompanies it. It describes the scientific and institutional programs supporting implementation of the RWSP and identifies any water quality needs not being met by the RWSP. Using this information, the County can determine any needed adjustments to the goals, policies, and RWSP guiding provision of wastewater services.

The remainder of this chapter describes the waters in King County. The chapters that follow describe County programs to manage and monitor water quality in the region; present the state of the waters in 2003; and outline continuing issues and needs concerning the health of county waters. The appendixes contain a glossary of technical terms used in this report and a list of Web sites that contain additional information .

King County Waters

The wastewater service area of western King County includes major freshwater streams and lakes and the marine waters of Puget Sound. The fresh waters are grouped into watersheds designated as Water Resource Inventory Areas (WRIAs). WRIAs were established by the State of Washington for the purpose of resource planning and management within each watershed's boundary. WRIA 08 is the Cedar-Sammamish watershed and WRIA 09 is the Duwamish-Green watershed. These two watersheds make up the majority of King County's wastewater service area. Figure 1 shows the boundaries and the major water bodies of each WRIA.



Cedar-Sammamish Watershed (WRIA 08)

Approximately 85 percent of the Cedar-Sammamish watershed lies within King County; the remaining 15 percent is in Snohomish County. The eastern portion of the watershed lies in the Cascade Range, and the western portion occupies the Puget Sound lowland. The major lakes studied by King County in WRIA 08 are Lake Sammamish, Lake Washington, and Lake Union.

The Cedar-Sammamish watershed has been dramatically altered in the last 150 years. This transformation resulted from the following activities:

- Building of the Landsburg Diversion Dam at the turn of the century by the City of Seattle to tap into the Cedar River as its main source of water
- Construction of the Lake Washington Ship Canal and Hiram M. Chittenden Locks between 1910 and 1920, which redirected the outlet of Lake Washington from its south end at the Black River to the north through Lake Union and the Locks and dropped Lake Washington's level almost 9 feet
- Dropping of the level of Lake Sammamish as a result of the change in the level of Lake Washington
- Draining of the wetlands along much of the shoreline of Lakes Washington and Sammamish as a result of their level changes
- Channelization of the Sammamish River in the early 1920s

Lake Washington

At 21,500 acres in area and 13 miles long, Lake Washington is the largest of the three major lakes in King County and the second largest natural lake in the State of Washington. The lake is 108 feet at its deepest point. Some of the beneficial uses of Lake Washington include fish rearing, spawning, and harvesting; wildlife habitat; swimming (primary contact recreation); and boating (secondary contact recreation). Lake Washington is the prime rearing habitat for juvenile salmon spawned in the Cedar and Sammamish Rivers and supports a number of resident fisheries.

By the late 1960s, all wastewater discharge to both Lake Washington and Lake Sammamish was ended, which removed about 75 percent of the nutrient inputs to the lakes. The subsequent water quality improvements were dramatic. Now phosphorus concentrations in Lake Washington are in large part a reflection of the amount of phosphorus entering the lake from the Sammamish River, nearshore runoff, and the Cedar River. The Cedar River contributes about 57 percent of the water to the lake but only 25 percent of the phosphorus due to its relatively low phosphorus concentrations. The Sammamish River contributes 27 percent of the water and 41 percent of the phosphorus to the lake.

Lake Sammamish

Lake Sammamish is the sixth largest lake in Washington and the second largest in King County. It is a major lake for recreational users such as fishermen, boaters, water skiers,

swimmers, and picnickers. It also provides rearing and migratory habitat for multiple salmon species and is home to a variety of warm-water fish, birds, and other wildlife. The beneficial uses of water bodies in the Sammamish basin include fish rearing, spawning, and harvesting; wildlife habitat; swimming (primary contact recreation); and boating (secondary contact recreation).

Lake Sammamish has historically suffered from excess phosphorus loading, with frequent late summer algal blooms and a dominance of the aquatic plant Eurasian milfoil (*Myriophyllum spicatum*). Over the five-year period following the cessation of wastewater discharges, water quality responded favorably showing a 50 percent reduction of phosphorus and algal concentrations and a 35 percent increase in water clarity. There remains cause for vigilance, though, as water quality often degrades with increasing development such as is occurring in this basin. Thus, in 1989 a *Lake Sammamish Management Plan* was developed based on the assumption that control of phosphorus loading into the lake would control primary productivity (algal blooms), water clarity, and dissolved oxygen. Measures to control phosphorus loading to the lake also result in many secondary benefits to the watershed, such as control of erosion and sedimentation and preservation of fish habitat, forest cover, and riparian cover.

Lake Union

Lake Union, at 580 acres in area and averaging 34 feet deep, differs significantly from the other two major lakes in the county because its hydrology was modified when the Fremont and Montlake cuts and the Hiram M. Chittenden Locks were constructed in 1911, connecting lakes Washington and Union with Puget Sound. This construction allowed intrusion of salt water from the Ship Canal. This intrusion now results in strongly stratified lake conditions: the more dense saline bottom water becomes devoid of oxygen early in the summer as bacteria thrive in the organically rich sediments at the bottom of the lake, limiting the amount of habitat available to fish. The lake and canal systems are the only migration route for the salmonids in the Lake Washington, Cedar River, and Lake Sammamish drainages.

In the past, Lake Union received wastewater discharges from local wastewater collection systems, from houseboats, and from discharges from ships, industry, and businesses along the shore. The lake has been impacted by fuel spills and other discharges from ships and onshore facilities. Pollution inputs from many of these sources have decreased—untreated wastewater was intercepted for treatment in the 1980s and the remaining CSOs are being controlled. In 1994, a CSO separation project in the University Regulator basin removed a significant amount of CSOs from the lake. The project included construction of a new stormwater outfall. A study to assess the impact of the stormwater discharge from the outfall found that there were no adverse impacts, that in fact sediment quality and the benthic community improved. A joint project between King County and the City of Seattle—the Denny Way/Lake Union CSO control project—is currently in construction and will be completed in 2005. The project will control all CSOs that discharge directly into Lake Union. Remaining CSOs along the Ship Canal will be controlled as part of the County’s RWSP (1999) and Seattle’s *Combined Sewer Overflow Control Plan Amendment* (2001).

Sammamish River

Long, straight, and open describes the Sammamish River, which since the late 1800s has been dredged, realigned, and stripped of much of its forest cover. The river was channeled and

dredged in the early 1960s for flood control and land use. Existing native vegetation was also removed from its banks, although recent recovery efforts are beginning to improve the condition of the riparian area. Generally, conditions in the Sammamish River are fair compared to the State Water Quality Standards and, as in most streams and rivers, water quality seems to be better in the upper reaches where development is minimal. The Bear-Evans Creek system, one of the major salmon producing streams in King County, drains into the Sammamish River. However, the river continues to experience degraded fish habitat and increased flooding and erosion—impacts from development that began in the 1970s and 1980s and that continue today.

Cedar River

The Cedar River is the largest tributary to Lake Washington and drains nearly 200 square miles from the crest of the Cascade Range to the lake at the City of Renton. The upper two-thirds of the basin is owned and managed by the City of Seattle and supplies drinking water to two-thirds of Seattle and its regional customers. The upper watershed is closed to the public and is managed under the *Cedar River Habitat Conservation Plan*. The lower portion of the river is primarily forested or rural, except near the mouth where the river passes through the City of Renton.

Streams

Many small streams exist in the Cedar-Sammamish watershed. Twenty-two streams are in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies: Bear-Evans, Coal, Ebright, Eden, Fairweather, Forbes, Idlewood, Issaquah, Juanita, Kelsey, Lewis, Little Bear, Longfellow, Lyon, May, McAleer, North, Pine, Swamp, Thornton, Tibbets, and Yarrow.

Duwamish-Green Watershed (WRIA 09)

The Green-Duwamish River watershed begins in the Cascade Range about 30 miles northeast of Mount Rainier and flows for over 93 miles to Puget Sound at Elliott Bay in Seattle. Historically, the White, Green, and Cedar (via the Black) Rivers flowed into the Duwamish River, and the system drained an area of over 1,600 square miles. The Green-Duwamish River watershed has one of the most altered hydrological ecosystems in the Puget Sound basin. To date, 98 percent of the Duwamish estuary has been filled, 70 percent of the flows of its former watershed have been diverted out of the basin, and about 90 percent of the once extensive floodplain is no longer flooded on a regular basis. These changes resulted from the following activities:

- Dredging, channelizing, and diking of the river for navigation and flood control between 1895 and 1980
- Filling and draining of the estuary tidelands to support industry and port activities between 1900 and 1940
- Diversion of the White River from the Green River to the Puyallup River for flood control in 1911
- Diversion of water for drinking water supply by the City of Tacoma in 1913

- Diversion of the Black and Cedar Rivers from the Duwamish River to Lake Washington in 1916
- Construction of the Howard Hanson Dam for flood control in 1962

As a result of these activities, the watershed has been reduced to 556 square miles and the ecosystem has been significantly altered. The major water bodies in the overlap of the Green-Duwamish watershed and the wastewater service area include the Green River, Duwamish River, and several small streams. There are no major lakes in the watershed.

Green River

The lower Green River and its valley are urbanized, consisting of dense commercial and industrial development as well as some of the fastest growing suburban communities in King County. Most of this area is incorporated, including the Cities of Seattle, Tukwila, Renton, Kent, and Auburn. Much of the commercial and residential development in the valley depends on a levee and dike system to contain the river. The middle Green River watershed includes rich farmlands and forestlands, as well as the cities of Covington, Maple Valley, Black Diamond, and Enumclaw; several state and county parks; and a salmon hatchery. The area is increasingly important as an affordable area for suburban and rural residences and hobby farms, is one of the largest remaining agricultural communities in King County, and provides extensive recreational opportunities for residents. The upper Green River extends from the crest of the Cascade Range, the river's headwaters, to the Tacoma diversion dam. The dam provides drinking water to the City of Tacoma and water for forest production for federal, state, and private landowners.

Duwamish River

The area around the Duwamish River is heavily urbanized, consisting of dense commercial and industrial development. The Duwamish River provides a passageway to the inland portions of the state, and thus has been an area of heavy industrial development. Concrete, glass, steel, and lumber factories, and construction and barge companies have all been a part of its economic fabric. Development in the Duwamish Estuary has resulted in the loss of approximately 98 percent of the estuary's former intertidal marshes and mudflats.

Streams

Among the small streams in this watershed, five occur in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies: Crisp, Mill, Newaukum, Soos, and Springbrook.

Puget Sound Marine Waters

Puget Sound is the southernmost of a series of glacially scoured channels, relatively protected by a single entrance 84 miles from the Pacific Ocean. It is a large estuary where freshwater draining from more than 10,000 streams and rivers mixes with saltwater entering from the Pacific Ocean through Admiralty Inlet and Deception Pass. The Sound consists of four major basins: the Main (Admiralty Inlet and the Central Basin), Whidbey, Southern, and Hood Canal Basins. All of the basins have different characteristics due to water circulation and underwater topography. Puget Sound is surrounded by 2,354 miles of shoreline, including beaches, bluffs, mudflats, deltas, and wetlands.

The average depth of Puget Sound is 348 ft. The Main Basin has depths greater than 920 ft and is shielded at the main entrance to the Sound by the Admiralty Inlet sill that impedes the exchange of deep waters. The Sound has near-oceanic salinity throughout most of the year and is supplemented with cold, nutrient-rich, low-oxygenated deep water upwelling off the Washington coast during the later summer and fall months. This upwelling creates a partially mixed two-layer system, with relatively fresh water flowing seaward at the surface and saline oceanic water returning landward at depth. Puget Sound has a mixed, semi-diurnal tidal cycle that is characterized by two unequal high tides and two unequal low tides each day with an average tidal exchange of 12 to 14 ft. Half of its water can be replaced with fresh ocean water in a tidal cycle. All of this helps the Sound maintain favorable water quality conditions.

Chapter 2

Water Quality Management Programs

This chapter describes King County’s water quality management programs, including its regional wastewater system and its programs for controlling pollutants at their source, for cleaning up contaminated sediments near combined sewer overflow outfalls, and for recovering resources.

Regional Wastewater System

The King County wastewater system serves approximately 1.4 million residents in a 420-square-mile service area. A total of 275 miles of pipes, 42 pump stations, and 19 regulator stations move wastewater from homes and businesses served by local agencies to two large regional treatment plants—the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton—and a small treatment plant on Vashon Island (Figure 2). These three plants treat wastewater to the secondary level. In addition, King County operates two combined sewer overflow (CSO) treatment plants at Alki and Carkeek Park in Seattle. The Alki and Carkeek plants provide primary treatment of excess flows that occur in the combined sewer system during storm events.

Secondary Treatment Plants

The federal Clean Water Act states that all wastewater collection and treatment facilities that discharge effluent into surface waters are required to have a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued by the Washington State Department of Ecology (Ecology) and set limits on the quality of effluent discharged from point sources such as treatment plants and industrial facilities. King County has NPDES permits for its West Point, South, and Vashon Treatment Plants. The West Point NPDES permit also includes the Alki and Carkeek CSO plants and the CSO outfalls.

The treatment process is an intensive and controlled version of the biodegradation of organic material that occurs in the natural world. Wastewater coming into the plants undergoes a series of treatment processes. The first is preliminary treatment, which screens out large items such as sticks, cans, and rags and then settles out heavy suspended material such as sand and grit. The next process is primary treatment. Here, wastewater flows through large settling tanks (primary sedimentation tanks) that allow up to 60 percent of suspended material to settle out. This treated water, called primary effluent, is then directed to the secondary aeration tanks. Whereas primary treatment relies on settling to remove coarse suspended material, secondary treatment uses aerobic bacteria to consume and digest the fine organic material in solution. The bacteria

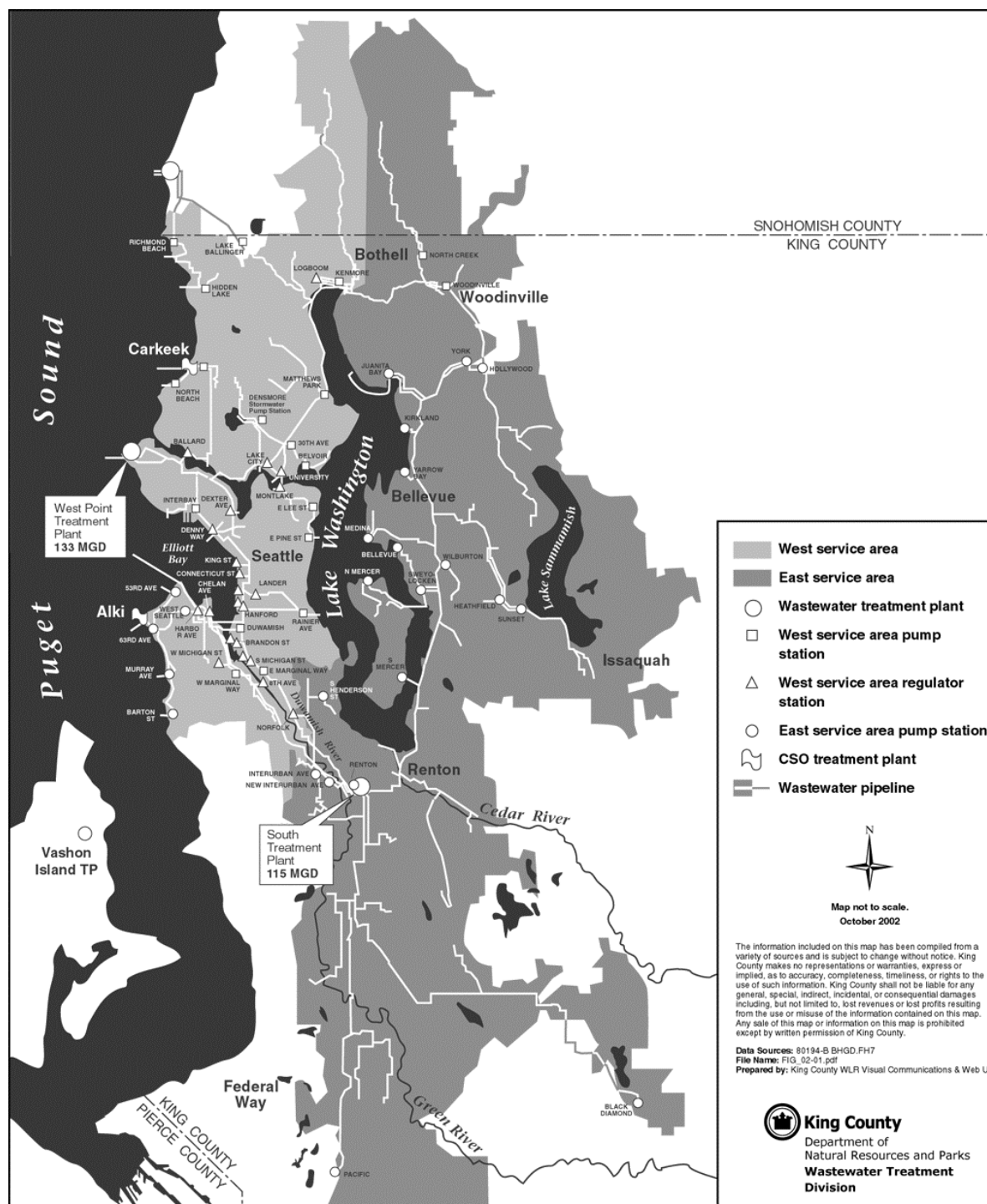


Figure 2
King County Regional Wastewater System

are called “aerobic” because they need air to survive. In the secondary treatment process, oxygen is bubbled into large aeration tanks where bacteria consume the dissolved organic material. After time, this mix of bacteria and primary effluent moves into large tanks (secondary clarifiers) that allow the bacteria and other fine material to settle out, removing 90 percent or more of pollutants. This highly treated water, called secondary effluent, is then disinfected with chlorine, sometimes dechlorinated, and pumped to an outfall that diffuses it deep in Puget Sound.

Solids are generated at each point in the treatment process. The heavier sand and grit collected from the preliminary treatment process are disposed of in a landfill. Solids collected from the primary sedimentation tanks and secondary clarifiers (termed sludge) are thickened by a dewatering process to 10 to 20 percent of their original volume and conveyed to large aboveground digesters. Here, anaerobic bacteria (bacteria that need no oxygen) digest the sludge for three to four weeks, producing a byproduct called biosolids—a nutrient-rich organic material used as compost or fertilizer in agriculture and forestry.

Both the West Point and South Treatment Plants also produce reclaimed water, which is secondary effluent that receives additional treatment using sand filters or other processes to produce non-potable water for irrigation, industrial processes, and in-plant use at the treatment plants.

South Treatment Plant

The South Treatment Plant, located on Monster Road in Renton, treats wastewater flows from customers in the lower Green River basin, suburban cities east of Lake Washington, and Seattle’s Rainier Valley. The plant provides secondary treatment of wastewater and treats about 20 million gallons (MG) per year of septic tank solids from throughout the region as well as sludge from treatment facilities in neighboring areas such as Snoqualmie Valley cities and Vashon Island. The South plant is current holder of an Association of Metropolitan Sewerage Agencies (AMSA) Platinum Award for excellent operation.

The South Treatment Plant is designed to manage a monthly wet-weather average flow of 115 million gallons per day (mgd). The effluent pumping capacity at the South Treatment Plant was recently upgraded to handle a peak flow of 325 mgd. The outfall in Puget Sound discharges secondary effluent 10,000 feet from shore at a depth of 625 feet into the denser deeper water layer. The increasingly diluted effluent plume moves southward in the Sound, remaining at or below a depth of 425 feet.

West Point Treatment Plant

The West Point Treatment Plant, located on the shore of Puget Sound in Discovery Park, provides secondary treatment for wastewater from customers located in the greater Seattle area and in southwest Snohomish County. It is the largest plant in the King County system, designed to manage an average wet-weather, non-storm flow of 133 mgd and a peak wet-weather flow of 440 mgd. After treatment, the secondary effluent is discharged through an outfall to Puget Sound. The outfall discharges 3,600 feet from shore at a depth of 240 feet. The increasingly dilute effluent plume flows northward most of the year, out of Puget Sound. The West Point plant is current holder of the Association of Metropolitan Sewerage Agencies (AMSA) Gold Award for excellent operation.

The plant is designed to provide secondary treatment for up to 300 mgd. Capacity between the 300 mgd capacity for secondary treatment and the 440 mgd peak capacity of the plant is used to manage captured CSO. The plant provides these CSO flows with primary treatment, disinfection, and dechlorination.

Vashon Treatment Plant

The Vashon Treatment Plant is located just northeast of the unincorporated Town of Vashon. This secondary treatment plant was constructed in 1975 and operated by the Vashon Sewer District until November 1999 when King County assumed responsibility for the plant. The plant was designed to manage a monthly average flow of 0.264 mgd and a peak flow of approximately 1.0 mgd. After secondary treatment and disinfection, the effluent is discharged through an outfall to Puget Sound. The outfall discharges 1,300 feet offshore of the eastern shoreline of the island at a depth of 41 feet.

The treatment plant has a history of numerous NPDES permit violations. Since King County assumed responsibilities for plant operations and facilities, many improvements have been made to enable the plant, though it is close to its design capacity, to operate more consistently. Improvements include removal of hydraulic restrictions in the outfall line to increase its peak-flow handling capacity, addition of a new ultraviolet disinfection process, improvement of sludge handling processes, and enhancement of the electrical and water utilities. In addition, to assure all permit limits will be met in the future the plant will be replaced by a new higher capacity facility by 2006.

Other wastewater-related improvements were completed on Vashon Island. A new community treatment system at Buelah Park and Cove was built and began operation. This system can serve up to 75 homes at this time. In addition, King County also began operation of the Bunker Trail vacuum collection system and conveyance system. This system includes one new vacuum station and four new pump stations and has the capability to serve up to 18 residences and businesses near the Washington State Ferry landing on the northeast side of the island. It transfers wastewater to the Vashon plant for treatment.

Treatment Plant Flows and NPDES Compliance in 2003

King County's facilities continue to be in compliance with the terms and conditions of its NPDES permits, and so are in compliance with the Washington Water Pollution Control Law and Federal Water Pollution Control Act (The Clean Water Act).

Despite the fluctuation of flow and influent composition, the South plant's secondary treatment process consistently produces high quality secondary effluent. In 2003, the South Treatment Plant managed an average flow of 74-mgd with a daily maximum of about 166-mgd. Treatment efficiency remained high and consistent. There was one exception to the NPDES discharge permit for the South Plant. South Plant exceeded the 400 CFU/100 mL weekly maximum Fecal Coliform limit in July 2003. This exception was related to a switch from chlorine to 12.5% sodium hypochlorite for disinfection. There were twenty-one exceptions to the Class-A reclaimed water permit limits. All of the reclaimed water exceptions were in regards to the Total Coliform permit conditions. The increase in reclaimed water exceptions was also related to the switch from chlorine to hypochlorite for secondary effluent disinfection. Secondary effluent is the feed water for the South Plant reclaimed water facility. Efforts to optimize

disinfection of secondary effluent with hypochlorite should lead to greater compliance with the Class-A Reclaimed Water Total Coliform permit conditions.

The average flow through the West Point Treatment Plant was about 109 mgd with a daily maximum of 392 mgd. There were no permit limit violations in 2003.

At the Vashon plant, the average flow in 2003 was 0.132-mgd with a maximum monthly average of 0.218-mgd. There were six NPDES permit exceptions, all related to suspended solids.

In December of 2003 negotiations with Ecology were completed on the renewal of the West Point NPDES Permit. The renewed West Point permit was issued in late December and became effective January 1, 2004. There were some changes from the permit that had applied from 1996-2003. They included:

- West Point
 - Minor modifications to mixing zone boundaries
 - Minor modifications to chlorine limits
 - Addition of a percent removal requirement of 80% in the wet season
 - More explicit recognition that the plant functions as a secondary treatment facility and a CSO treatment facility in the wet season, with some different operational conditions applied at times in the wet season
- Carkeek and Alki CSO treatment facilities
 - Addition of Chlorine and Fecal Coliform limits on discharges starting in January 2006
 - Compliance with solids removal requirements will be done differently, by calculation percent removal annually rather than by comparison of event solids concentrations to a surrogate solids concentration as done previously

Combined Sewer Overflows

The combined sewer system carries both wastewater and stormwater. The City of Seattle is the only wastewater agency served by King County that has such a system. This combined system is primarily in the West Point service area. The other local collection systems are separated sewer systems. These separated systems carry wastewater to large King County pipelines, while “separately” directing stormwater to the nearest water body. Depictions of combined and separated sewer systems are shown in Figures 3 and 4.

During periods of heavy rainfall when flows exceed the capacity of the secondary and CSO treatment plants, untreated discharges of wastewater and stormwater from combined sewers are released via outfalls directly into marine waters, lakes, and rivers. These releases are called combined sewer overflows (CSOs). Approximately 90 percent of the CSO volume is stormwater and only 10 percent is wastewater. Figure 5 shows the locations of CSO outfalls in the King County system.

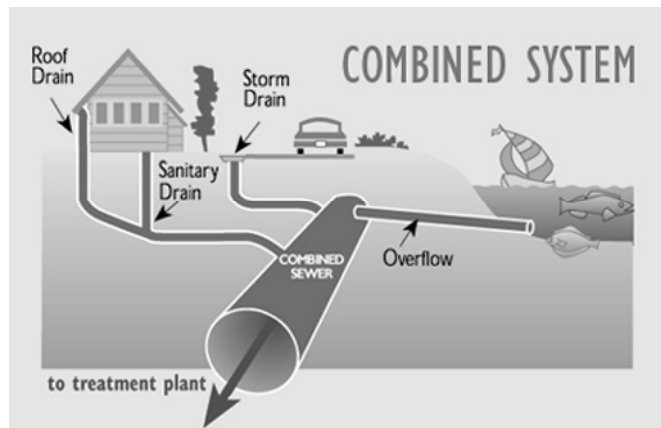


Figure 3
Typical Combined Sewer System

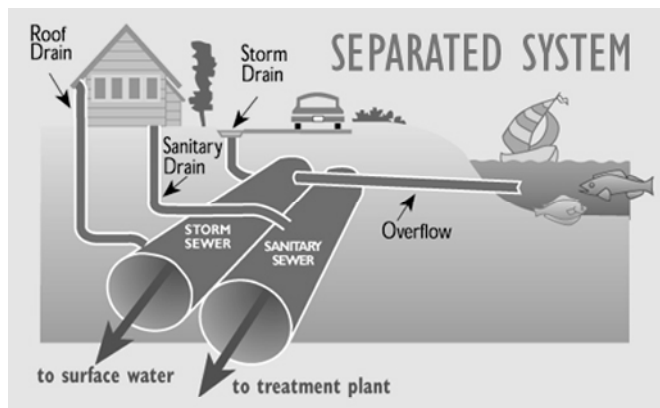


Figure 4
Typical Separated Sewer System

King County & City of Seattle Combined Sewer Overflows

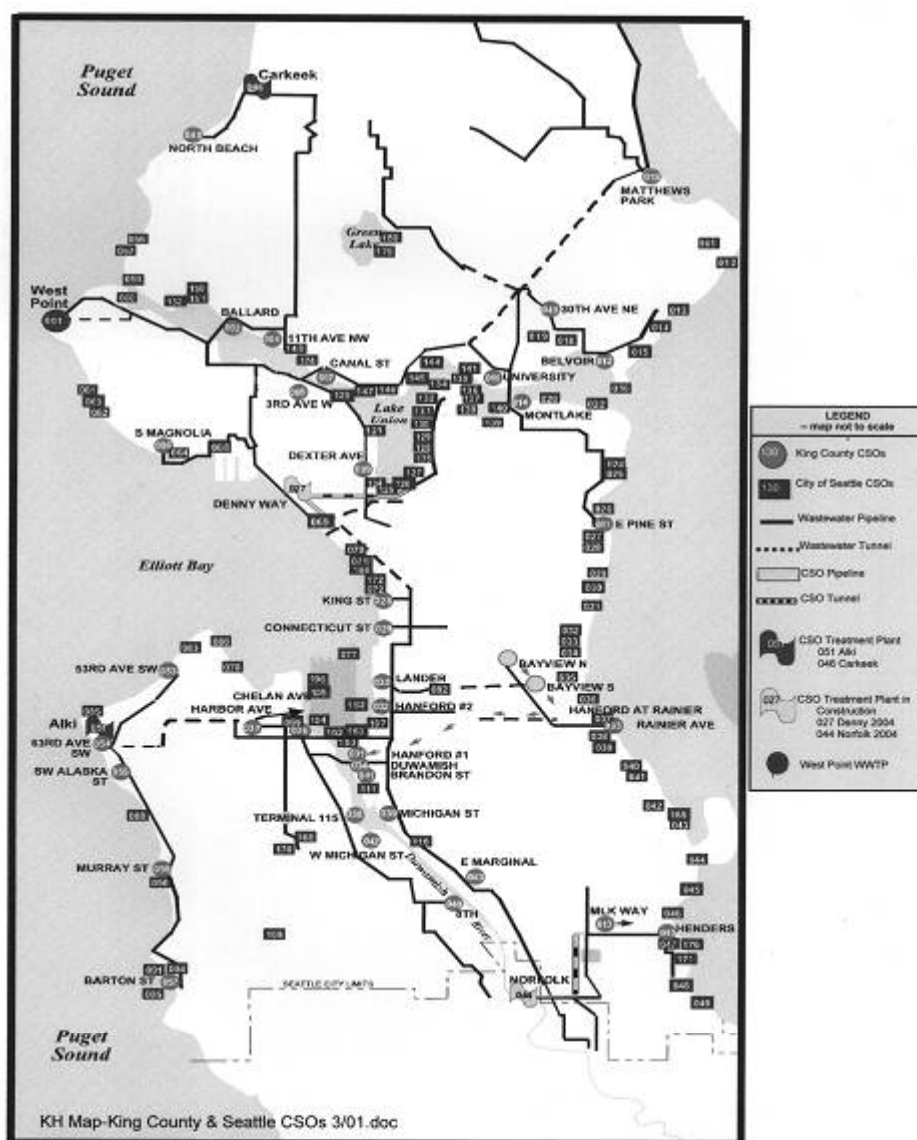
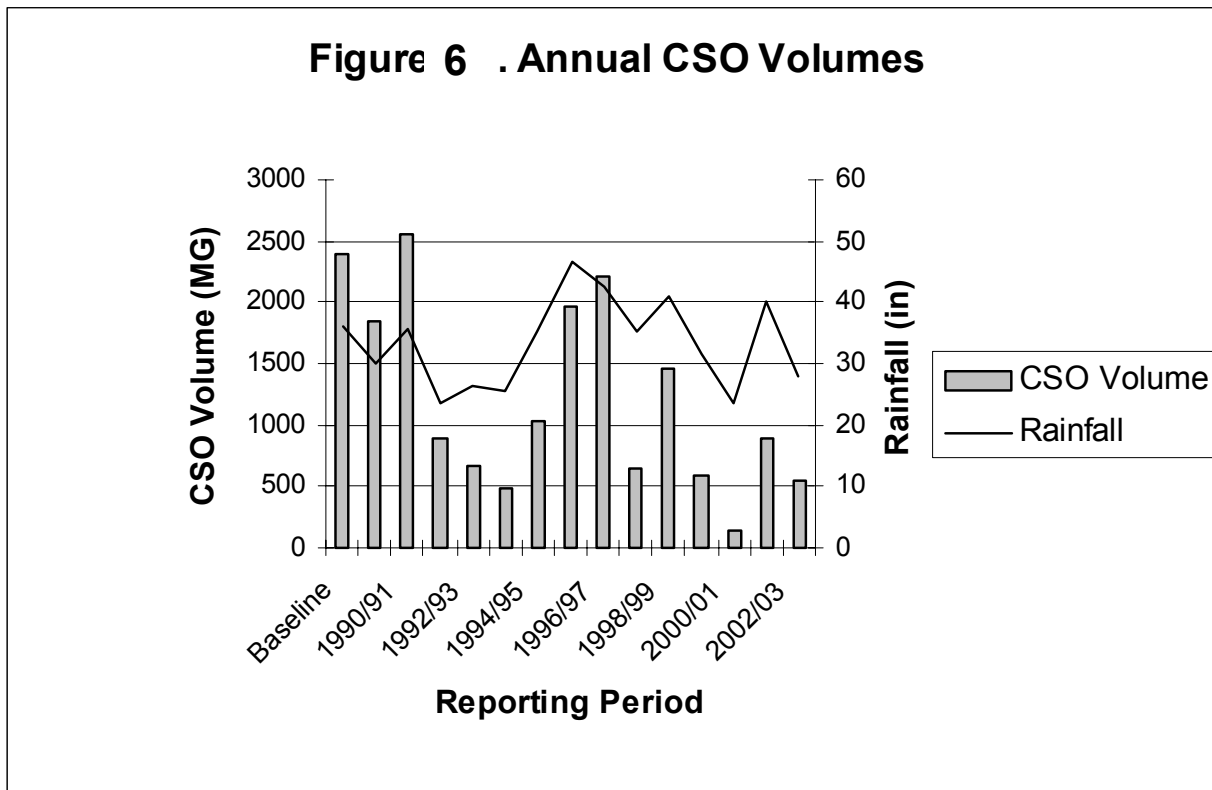


Figure 5
King County and City of Seattle Combined Sewer Overflows

CSO sites that meet the Washington State standard of “an average of no more than one untreated discharge per year per outfall” are referred to as “controlled.” Those that do not meet the standards are referred to as “uncontrolled.” Uncontrolled CSOs occur year-round, mostly between September and March; single-event discharges from controlled CSOs usually occur between December and February during the largest, most intense storms.

Combined Sewer Overflow Activity in 2003

The goal of King County’s CSO control program is to bring all CSOs into controlled status by 2030. The CSO control program, as outlined in the RWSP, is a continuation of a CSO control program started in the 1970s. The total number of CSO events (using Ecology’s newer 24-hour inter-event interval definition) in 2002/2003 was 157, with total system volume of 549 MG. Of these overflows, 36 events occurred in the West Point north service area and 121 events in West Point’s south service area. These numbers are approximately 70 percent lower than the baseline estimated in 1981 through 1983, demonstrating CSO control progress over time (Figure 6). More information about specific CSOs can be found in the *2002/03 Combined Sewer Overflow Annual Report*.



During 2003, work continued on two major CSO control projects. The Denny Way/Lake Union project will control all overflows into Lake Union and will control the County’s largest CSO at Denny Way near Myrtle Edwards Park in Seattle. The Henderson/Martin Luther King/Norfolk project will control three CSOs: two CSOs into Lake Washington and one into the Duwamish River. These projects will be complete in 2005.

Carkeek CSO Treatment Plant

The Carkeek plant and pump station were originally constructed to provide primary treatment to all service area flows reaching the plant. In 1994, new pipelines were completed to transfer base wastewater flows—defined by the Washington State Department of Ecology (Ecology) as 2.25 times the service area’s average wet weather flow (AWWF) or up to 9.2 mgd—to the West Point Treatment Plant. Flows exceeding 9.2 mgd are stored at the Carkeek plant. Flows that exceed the storage capacity of the Carkeek plant are provided primary treatment, disinfection, and discharge to Puget Sound from the Carkeek plant. The Carkeek outfall discharges 2,100 feet offshore at a depth of about 200 feet.

The transfer of flows from Carkeek to the West Point Treatment Plant since 1994 has reduced the amount of primary effluent discharged from the Carkeek Treatment Plant from approximately 1,351 to approximately 60 MG per year on average.

Alki CSO Treatment Plant

The Alki Treatment Plant was originally constructed to provide primary treatment to all service area flows from the Alki area in West Seattle. Similar to the approach used at the Carkeek plant, the West Seattle Tunnel was constructed in 1998 to transfer base combined sewage flows—up to 18.9 mgd—from Alki via the Elliott Bay Interceptor to the West Point Treatment Plant for secondary treatment. Flows in excess of 18.9 mgd are provided primary treatment, disinfection, and discharge to Puget Sound from the Alki plant. The Alki outfall discharges 1,900 feet offshore at a depth of 143 feet. The transfer of flows from Alki to the West Point Treatment Plant since 1998 has reduced the amount of primary effluent discharged from the Alki Treatment Plant from approximately 2,500 to less than 10 MG per year on average.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are discharges of wastewater from separated sewer systems. SSOs can flow from manholes, broken pipes, or pump stations onto city streets, into water bodies, and even as backups into basements. SSOs occur on rare occasions, typically during extreme storm events and power outages. Minimizing the discharge of untreated wastewater is fundamental to the mission of the Wastewater Treatment Division, and extensive resources have been committed to maintaining the integrity of the system and preventing SSOs. The County’s Maintenance and Asset Management groups maintain a regular schedule of inspection, maintenance, and repair of facilities to prevent mechanical failures and SSOs.

Sanitary Sewer Overflow Activity in 2003

Table 1 shows that King County reported 13 SSOs in 2003, which is below the annual average of 15 (based on averages over a 15-year period). Two of the SSOs flowed into Puget Sound, four into Lake Washington, one into the Ship Canal, one into the Sammamish River, and one into Phantom Lake.. Three overflows were contained before reaching any water bodies, while two more were contained in on-site wetlands. The overflows ranged in size from 100 gallons to 1.3 million gallons. While there is some short-term risk to public health and the environment from SSOs, there are no long-term effects from this volume of release. In all cases, the County’s overflow response procedures were implemented. These procedures include posting the area, sampling, and public notification as appropriate for the nature of the overflow.

Table 1
2003 Sanitary Sewer Overflows

Date	Location	Estimated Volume (gallons)	Duration (hours)	Discharge Type	Receiving Waters	Reason for Overflow
Jan. 3	Carkeek	900,000	10	Untreated wastewater	Ground contained	Broken pipe
Jan. 30	Juanita Bay Pump Station	100	<0.5	Untreated wastewater	Lake Washington	Mechanical failure
Mar. 4	Richmond Beach PS	41,300	0.58	Untreated wastewater	On-site wetland; contained	Mechanical failure
Mar. 19	Richmond Beach PS	34,000	0.38	Untreated wastewater	On-site wetland; contained	Mechanical failure
July 03	Clark Fork Trunk	1000	+4	Untreated wastewater	Ground contained	Obstruction
July 07	Sweylocken Pump Station	45,000	<0.5	Untreated wastewater	Ground contained	Break in force main due to construction.
Aug. 01	Lakeland Hills MH 5	1000	<1	Untreated wastewater	Phantom Lake	Obstruction
Sept. 07	Murray Pump Station	40,000	1.0	Untreated wastewater	Puget Sound	Loss of Utility Power.
Oct. 20	Kenmore PS	1,700,000	3	Untreated wastewater	Sammamish River	Record-setting rain
Oct. 20	Lakeline flapgate	N/A	2.5	Untreated wastewater	Lake Washington	Record-setting rain
Oct. 20	Sweylocken Pump Station	135,000	0.5	Untreated wastewater	Mercer Slough & Lake Washington	Electrical Failure: Heavy rains.
Oct. 20	Enetai Interceptor MH R08-01B	N/A	N/A	Untreated wastewater	Lake Washington	Pressure MH cover found undone. Heavy Rains.
Dec 04	Barton Pump Station	10,000	<0.5	Untreated wastewater	Puget Sound	Loss of Utility Power.

Planning for Future Capacity

To make sure that there is adequate time to plan, design, and build new wastewater management facilities to be ready when needed, King County must continually analyze and monitor its system. As a result of these analyses, the King County Council adopted the RWSP in 1999 to provide needed capacity through 2030. Central to the plan will be the construction of a new treatment plant—the Brightwater Treatment Plant, which will be online by 2010.

The following analyses are part of King County’s ongoing planning efforts:

- Projected population growth, type, and location using Puget Sound Regional Council data
- Economic changes affecting population growth
- Trends in water use and conservation

- Estimates of the quantity of stormwater and groundwater leaking into the system via infiltration and inflow
- Actual measured flows and solids loading over time
- New wastewater sources via contracts for service or septic system hookups

This information is then modeled and compared to existing facilities to determine where and when additional capacity must be provided by new facilities. The *2004 RWSP Update Report* describes this activity in more detail.

Infiltration and Inflow

In general, the County finds that needs for additional capacity in its wastewater system are driven less by population growth and more by the intrusion of clean water into pipes through inappropriate connections to the sewer or cracks in the pipe – called infiltration and inflow (I/I). I/I affects the hydraulic peak flow that must be managed by pipelines and plants. Measures such as water conservation have little benefit in comparison to these wet weather demands. The County is currently investigating various approaches to control I/I. However, because control alternatives are difficult to implement and have not yet been demonstrated to be successful, the County is not factoring reduced I/I into current planning. Should current pilot projects provide significant control of I/I cost-effectively, similar approaches will be considered to free up capacity for wastewater in place of building additional capacity.

Water Conservation

Water conservation minimizes the loss of potable water into the wastewater stream, thus decreasing the demand for this valuable resource from fish-bearing streams and decreasing the baseflow of wastewater to the treatment plants. Water conservation projects are being implemented as a form of “demand management” under the RWSP. The program has committed \$300,000 per year for a five-year program. The program has two areas, public education and implementation of water conservation retrofits that result in substantial water conservation savings.

Water Conservation Activities in 2003

With 2003 water conservation funding established as part of the RWSP, King County partnered with Seattle Public Utilities to conduct water audits of its major facilities. Based on the audit findings, conservation retrofit projects were prioritized, designed, and implemented. In 2003, King County park, pool, public health, district court, animal shelter and sheriff precinct facilities are being audited and water conserving fixtures, including toilets, urinals, faucets, faucet aerators, and timed showers are being installed. The fixtures are projected to save over 4,000,000 gallons per year and will pay for themselves in less than 2 years. Because of the high public use at a number of these facilities, they offer a wonderful venue for water conservation-related informational signage.

King County launched a water conservation Web site and contributed to the Water Conservation Coalition of Puget Sound’s Regional Public Awareness Campaign, Water Use It Wisely. Bert the Salmon water conservation baseball cards were handed out at a variety of events and venues.

Septic Conversions

The King County Comprehensive Plan establishes a goal of having the entire Urban Growth Area (UGA) sewer by the year 2020. The King County Wastewater Treatment Division uses this goal as a planning assumption for determining future wastewater capacity for its wastewater service area. In practice, achieving the comprehensive plan goal will require local sewer agencies to extend their service to currently unsewered areas within the regional wastewater service area. It will also require local sewer agencies to develop or update their policies to assist residents in acquiring wastewater service or require them to connect under circumstances less severe than outright system failure.

Septic Conversion Activities in 2003

The Seattle-King County Public Health Department continues to work with the King County Department of Natural Resources and Parks to develop a database of property owners who are currently on septic tanks. These owners will receive information about maintaining their systems per Title 13 of the King County Board of Health.

Source Control Programs

King County operates three source control programs: the Industrial Waste Program, Local Hazardous Waste Management Program, and Sediment Management Program.

The Industrial Waste and Local Hazardous Waste Management programs work to control pollutants at their source, keeping them out of the wastewater system and, in turn, out of surface waters and the environment. The two approaches complement one another, enhancing the County's ability to address pollutants from a wide variety of sources. Generally speaking, the Industrial Waste Program focuses on larger businesses in a regulatory manner, issuing permits and discharge authorizations under a federally mandated pretreatment program. The Local Hazardous Waste Management Program focuses on smaller businesses and on households in a non-regulatory manner, providing technical assistance, resources, and education under a State-mandated program. The Sediment Management Program is focused on cleaning up contaminated sediments near CSO outfalls and, in doing so, eliminating a source of pollution to the environment.

Industrial Waste Program

This section describes the Industrial Waste Program, the Lower Duwamish Waterway Source Control Project that was begun in 2002, and other activities completed through the program in 2003.

Description of the Program

The Industrial Waste Program regulates industrial wastewater discharged into the King County wastewater system. The core work of the Industrial Waste Program involves identification of conditions under which companies may discharge to the County wastewater system, and then following up with monitoring, inspections, and enforcement. The purpose of these activities is to see that industries treat wastewater before discharging it in order to control harmful substances such as metals, oils, acids, flammables, organic compounds, gases, or solids. This

program protects surface water quality, the environment, public health, the wastewater system and its workers, and biosolids quality.

The Industrial Waste Program may regulate any industry, from largest to smallest, if the industry discharges wastewater to the wastewater system. To do this, the Industrial Waste Program issues two main kinds of discharge approvals: permits and discharge authorizations. Permits are issued to significant industrial users industries discharging more than 25,000 gallons per day and/or in federally regulated categories. The U.S. Environmental Protection Agency (EPA) requires at least 20 categories of industries to get permits, whatever their size or quantity of wastewater. Permits have more comprehensive requirements than discharge authorizations and require a company to self-monitor its discharge.

Industrial waste investigators inspect facilities before issuing discharge approvals and also inspect those with approvals to see that they are complying with regulations. Most are companies that are required to self-monitor their discharges. Industrial waste specialists take verification samples at facilities to see whether wastewater complies with regulations. When violations are found, follow-up inspections and sampling are done to determine that violating conditions have been eliminated.

The Industrial Waste Program issues a notice of violation when a company discharges more contaminants or volume than allowed, violates conditions of its discharge approval, or fails to submit required reports. For enforcement, the Industrial Waste Program uses tools such as compliance schedules, fines, charges for monitoring and inspections, and cost recovery for damages.

Lower Duwamish Waterway Source Control Project

A new effort by Industrial Waste, in support of the Sediment Management Program, was initiated in 2002. The Lower Duwamish Source Control Project is headed by the State Department of Ecology. Its purpose is to identify and manage sources of chemicals to site sediments in coordination with sediment cleanups. Its goals are to minimize the potential for chemicals in sediments to exceed the Sediment Management Standards (WAC 173-204) and the Lower Duwamish Waterway sediment cleanup goals.

As part of this project King County Industrial Waste and Seattle Public Utilities are spearheading a joint inspection project together with Public Health – Seattle and King County, and King County’s Hazardous Waste Program. Participating agencies inspect businesses for discharges to stormwater, wastewater, and combined sewers and for compliance with hazardous waste regulations. Involving multiple agencies in a variety of different regulations reduces redundancy and costs. Each business will receive one inspection unless the inspectors find problems that need follow-up visits.

Work began in January 2003 with a training session attended by over 30 inspectors from six different agencies. Inspections began shortly thereafter in the Duwamish-Diagonal drainage basin, a large basin that extends east and north from the shared King County and Seattle drainage pipe at Diagonal Way. An area of sediments near this pipe is one of the early action sites to be cleaned up through the Lower Duwamish Superfund Site process. Following completion of inspections in the Duwamish-Diagonal basin, inspectors will move to other basins draining to other early action sites as remediation efforts are undertaken.

In 2003 inspectors completed 439 inspections of businesses in the Duwamish Diagonal Basin, 126 screening inspections and 313 full inspections. Of the full inspections, 62% were requested to take some sort of corrective action. The most common problems were related to stormwater or hazardous waste management.

Industrial Waste Program Activities in 2003

During 2003, the Industrial Waste Program had 133 permits and 298 discharge authorizations in effect and conducted 315 inspections.

Table 2 gives perspective on Industrial Waste enforcement activities, showing the number of compliance samples collected versus the number of violations detected. Following the table is a brief summary of the enforcement actions that were taken.

Table 2
Number of Discharge Compliance Samples and Discharge Violations in 2003

Parameter	Compliance Monitoring	Post-Violation	Discharge Violations
Cyanide	210	4	2
Metals	474	10	13
Organics			
BNA	45		1
VOA	237		1
Fats, Oils, and Grease (FOG)			
Total	0		
Polar*	42		
Non-polar	298		
pH (field)**	595	4	10
Surcharge	269		

*The "Polar" (animal-vegetable) FOG analyses are for the visual free-floating FOG test, not laboratory analyses.

**The number of pH samples is somewhat misleading because it shows only discrete pH samples collected and analyzed in the field. The number does not include readings from continuous pH measurement.

During 2003, Notices of Violation were issued to 34 companies for 142 violations. Several companies had multiple violations in more than one category. None of the violations caused NPDES violations at the King County treatment plants. In summary, these violations consisted of the following:

- 24 companies had 49 discharge violations.
- 7 companies had 30 permit/code violations.
- 10 companies had 63 reporting violations.

These violations resulted in the following enforcement actions:

- 7 companies were placed on compliance schedules.
- 14 companies were billed a total of \$21,246 in post-violation charges.
- 2 companies were issued fines totaling \$123,750 and \$7,500 in avoided costs.

Local Hazardous Waste Management Program

King County participates in a regional program that addresses hazardous wastes from small businesses and households. This program, called the Local Hazardous Waste Management Program, is a consortium of agencies in King County (Water and Land Resources and Solid Waste divisions), the City of Seattle (Public Utilities), the Seattle-King County Public Health Department, and the Suburban Cities Association. Operated out of the County's Water and Land Resources Division, the program provides technical assistance, reimbursement, and recognition to businesses that generate small quantities of hazardous waste. It also provides collection services for household hazardous wastes as well as public education aimed at proper handling and reduction in use of hazardous household products.

The Local Hazardous Waste Management Program oversees King County's Integrated Pest Management (IPM) Program for all County operations. Through IPM, there have been substantial reductions in total pesticide use by the County (by more than 60 percent since 2000) and proper disposal of tons of old pesticides that the County no longer needs. King County has incorporated many innovative alternative pest management approaches and is working with local cities to share experiences and resources.

These activities helped to reduce air emissions within the wastewater system caused by solvents and other hazardous air pollutants. Potentially problematic chemicals that could affect the secondary treatment processes have been reduced. By reducing hazardous waste, heavy metals and organics that accumulate in the solids are reduced, making biosolids products more useable and more acceptable to customers and the public. The program ultimately reduces the discharge of heavy metals and organic chemicals in plant effluents into Puget Sound.

Hazardous Waste Program Activities in 2003

In 2003, the Local Hazardous Waste Management Program:

- Conducted over 2,800 site visits to businesses by the field inspectors.
- Inspected and educated businesses resulting in their reduction of hazardous waste generation by 8,500 pounds per year.
- Convinced businesses to divert 19,000 pounds a year of improperly disposed hazardous waste to proper disposal. This total includes 1,300 pounds a year of mercury-bearing amalgam waste from the sewer and 13,100 pounds of mercury-contaminated solids from disposal as solid waste.
- Helped businesses to move 1,800 gallons of hazardous chemicals from unsafe storage near floor drains or outdoors into contained, covered storage areas.
- Helped businesses safely dispose of 17,600 pounds of stockpiled chemicals before they could become a problem.

This field team success story is an example of how the program's teams work together to gain the confidence of businesses and achieve the kind of results documented mentioned above. A Request for Action (RFA) to the Response Team at an auto body shop resulted in a joint effort by the Response and Audit teams. When a Response team member visited this site, the business owner was open and receptive, inviting the investigator in and asking for help with the disposal of accumulated hazardous wastes. A history check revealed a visit by another

Response team member several months earlier. That investigator's visit apparently planted the seeds for compliance and housekeeping improvement in the mind of the business owner. He was receptive to assistance during the second visit, after being somewhat suspicious during the first. The first visit apparently allayed the business owner's fears and the second enabled him to ask the questions he was no longer afraid to ask.

Sediment Management Program

To address the potential for resuspended contaminated subaquatic sediments to pollute the broader environment and harm aquatic species, King County developed the *Sediment Management Plan* (SMP) in 1999 as directed in the RWSP. The plan identified and evaluated programmatic long-range remediation alternatives for consideration at seven sites near King County CSO outfalls. These seven sites represent Ecology's currently designated contaminated sediment sites in Puget Sound and the Duwamish River for which the County has some responsibility. These sites are near the following King County CSO outfall sites: Hanford Street, Lander Street, Duwamish Siphon, Brandon Street, King Street, Denny Way, and Chelan Avenue.

Ecology is granted legal authority under Washington Administrative Code (WAC) 173-204, Sediment Management Standards, to direct the identification, screening, ranking, prioritization, and cleanup of contaminated sediment sites in the state. Once a site is ranked and placed on the contaminated sites list, it may then be considered for cleanup. WAC 173-204 provides for the voluntary cleanup of contaminated sediments with oversight and guidance by Ecology. Alternatively, Ecology or EPA may initiate enforcement actions (including cost recovery) under the Washington Model Toxics Control Act (MTCA) or the federal Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), also known as Superfund.

The County is moving ahead with the cleanup of these seven identified sites, using the voluntary approach whenever possible and participating in State or Federal cleanup processes that have already begun. The County agreed with the City of Seattle, the Port of Seattle, and Boeing to undertake the first steps in the cleanup of the Lower Duwamish Waterway (LDW)—sharing the cost of developing the Remedial Investigation and Feasibility Study (RI/FS). The RI/FS is being done under an Administrative Order of Consent signed by the four parties, by EPA, and by Ecology.

Two of the seven sediment cleanup sites are in the East Waterway at the mouth of the Duwamish River. EPA has expanded an existing Superfund site along the east shoreline of Harbor Island to cover the entire East Waterway. This expansion has slowed the dredging efforts by the Port of Seattle under its East Waterway Harbor Improvement Project. Cleanup began at the end of 2003 in the most contaminated portion of the East Waterway. The remainder of the cleanup actions are still being determined and scheduled. The Superfund cleanup requirements for the East waterway could also result in changes in the priority and schedule of CSO control projects if other pollutant source control measures are not adequate.

Sediment Management Program Activities in 2003

Accomplishments in 2003 under the Sediment Management Program are as follows:

- The Phase I remedial investigation (RI) report on the LDW was completed, including proposal of candidate sites for early action cleanups. Work was started on two of the proposed cleanup actions
- Started the final phase of developing a near-field discharge model for CSOs identified in the SMP as necessary to gain state approval of proposed cleanup actions and determine recontamination potential
- Under a Memorandum of Agreement with the Washington State Department of Natural Resources, drafted a process for cleanup decisions on State-owned aquatic lands and completed general plan of operations for cleanup site leases that will streamline all future leases
- Started the Elliot Bay/Duwamish Restoration Program cleanup of the Duwamish/Diagonal CSO—one of the contaminated sediment sites on the State list and identified as an early action within the LDW Superfund site; scheduled to complete in early 2004
- Implemented innovative one-stop source control help for local businesses in the LDW Superfund site Duwamish/Diagonal basin by combining industrial waste, local hazardous waste, stormwater, and health department site inspection programs into one site inspection and technical assistance program (see the “Industrial Waste Program” section above)
- Started investigations on the Denny Way CSO - one of the contaminated sediment sites on the State list; cleanup will follow completion of the new Denny Way CSO project with its discharge through new offshore outfalls

Resource Recovery Programs

King County has long recognized that the liquids and solids leaving the wastewater treatment process are not “wastes” for disposal, but are useful resources that can be recycled to benefit the environment or replace other high-demand resources. The County currently recycles three of these resources as useful products: biosolids, methane (digester gas), and reclaimed water.

Biosolids

On average, King County produces approximately 128,000 wet tons of biosolids each year—all of which is recycled for use in forestry, compost, and agricultural applications. There are two ongoing efforts in King County’s management of biosolids: the recycling program and new technology assessment. The recycling program continues to produce Class B biosolids at all treatment plants by anaerobic digestion. Class B processing relies on application of the biosolids to a controlled-access site, such as a forest or agricultural field, to complete the pathogen reduction process. The assessment of new technologies is discussed.

Biosolids Activities in 2003

To ensure the appropriate use of biosolids, King County continued to monitor water quality of streams near biosolids application sites in 2003 and, as with previous years, found little effect to receiving waters from biosolids.

The Technology Assessment program is evaluating new technologies to increase the efficiency or reduce the potential impacts of solids processing, and that have the potential to produce

Class A biosolids. Pilot test programs and final reports have been completed on advanced biosolids dewatering/drying (Centridry™), vertical shaft aerobic thermophilic digestion (VERTAD™), anaerobic thermophilic digestion, anoxic gas flotation thickening (AGF) and solids pyrolysis/gasification using microwave energy (SAGE™). With the exception of the gasification process, all of the technologies performed sufficiently well to warrant additional demonstration or full-scale development in the appropriate situation. None of the technologies would eliminate or substantially reduce the number of digesters but all four of the viable technologies could ultimately be a significant element in the development of a Class A biosolids product.

In 2004, King County initiated a project to evaluate the best technologies and implementation strategies for production of Class A biosolids at the South and West Point Treatment Plants. The project will result in a detailed implementation plan to support decision-making processes regarding the possible conversion to Class A biosolids production.

Three upset or “pre-upset” conditions have been experienced at the West Point Plant in recent years. A digester upset can be caused by a variety of conditions and is usually characterized by increased odor production, decreased gas production and decreased or lost capacity to convert and stabilize flows. These solids processing problems indicate limitations to West Point’s effective capacity under certain conditions. A study of the causes and solutions was completed in 2003. It is anticipated that implementation of the needed changes can be completed within four years.

Methane (Digester Gas)

A byproduct of biosolids production is methane (digester gas). Both the West Point and South plants recover this gas, but each uses it differently. The South Plant sells the gas to Puget Sound Energy for distribution in its natural gas system; West Point uses the gas to fuel generators that produce electricity. This electricity is used to power plant operations and any excess electricity is sold to Seattle City Light.

Methane Recovery Activities in 2003

Production and use of methane continued at both plants in 2003. In addition, investigation of new uses and technologies progressed. As an outcome of that investigation, two new uses for methane will be implemented at the South plant. The first is a digester gas-fired boiler, which will provide heat for some plant facilities and operating processes. The digester gas-fired boiler was completed the end of 2003. The second is a fuel cell demonstration, which will use 20 percent of the plant’s gas production and will produce 1 MW of electricity. Construction of the fuel cell project was completed and began a 2-year demonstration period in February 2004. If the demonstration is successful the facility will be used on an ongoing basis.

Reclaimed Water

King County began producing reclaimed water at its West Point and South Treatment Plants in the early 1990s. This water is used in plant operations and irrigation. In 1997, the Water Reuse Policy Development Task Force adopted a needs statement recommending, “recycling and

reusing highly treated wastewater effluent should be investigated as a significant new source of water.”

To focus the County’s efforts to reclaim more water, a five-year *Water Reuse Work Plan* was transmitted to Council in December 2000. The plan recommended two primary implementation efforts: a technology demonstration project and a satellite treatment facility.

Under the RWSP, King County will meet the intent of this statement in part by evaluating this region’s need for a satellite treatment facility and its ability to support it. The County worked with a Stakeholder Task Force to solicit and rank nominations from public and private parties interested in partnering to implement water reuse demonstration projects. In all, 11 nominations representing 13 projects were received.

Each of these projects was ranked based on criteria developed with the Stakeholder Task Force. The criteria included factors such as cost per unit of reclaimed water, regulatory issues, community impacts and support, and integration with other county projects. The Sammamish Valley Reclaimed Water Production Facility, which would produce water for irrigation, ranked favorably on all the criteria and therefore received the highest overall ranking. Accordingly, this project was selected for implementation. King County began predesign on the facility in December 2001.

Reclaimed Water Activities in 2003

In 2003 the local community chosen for the site of the reclamation plant raised concerns about the suitability of the site. As a result Predesign will now look for alternative sites and configurations. The schedule for the project will be revised after confirming a new site for the facility.

Council, in a proviso to the 2004 County budget, required the submittal of a new report by April 15, 2004. The report will review how an interim satellite reclaimed water production facility in the Sammamish Valley will be consistent with the adopted goals and policies of the RWSP, will account for life-to-date expenditures, and will outline a revised scope and budget for the interim facility. The report will also demonstrate how the interim project will be related to and integrated with any future reclaimed water production at the Brightwater Plant.

Chapter 3

Monitoring the Health of King County Waters

In the Puget Sound region, water is an integral part of our surroundings, economy, and way of life. King County acts as a steward of these waters and is committed to keeping them clean. The quality of our waters has improved dramatically over the years as the result of the development of a regional wastewater collection and treatment system and our cooperative efforts to implement pollution control programs. The County's goal is to ensure that our actions are not degrading the beneficial uses of our valuable water resources. Understanding the health of our waters is the starting place for achieving this goal.

This section describes how the County measures the health of water bodies in its wastewater service area using chemical, physical, and biological indicators. It also describes how the County monitors these indicators in order to identify changes in water quality that warrant intervention and then take the necessary steps to restore and maintain the quality of county waters. Some of the monitoring programs are ongoing; some are special short-term studies.

Washington State Water Quality Standards

The primary objective of the federal Clean Water Act (CWA) is to restore and maintain the integrity of the nation's waters. This objective translates into two national goals: to eliminate the discharge of pollutants into the nation's waters and to achieve fishable and swimmable waters. The first goal is met through the National Pollutant Discharge Elimination System (NPDES) permit program, which sets limits on pollutants discharged from distinct and identifiable sources, called point sources, such as King County's wastewater treatment plants and municipal stormwater systems. The second goal is met by developing pollution control programs to meet specific water quality criteria for water bodies.

To meet the second CWA goal, the Washington State Department of Ecology (Ecology) put into regulation a classification-based system in which each water body is assigned to one of eight classes: four freshwater classes (Class AA, Class A, Class B, Lake Class) and four marine classes (Class AA, Class A, Class B, and Class C). In June 2003 Ecology adopted several changes to their standards reformatting water uses and criteria from the previous classification-based standards to use based standards. These changes reflect the latest scientific information and new state and federal requirements – all aimed at making our waters clean and safe for people, fish and wildlife. Tables 3.1 through 3.4 show the revised Washington State classification system and corresponding standards. EPA must approve these before they can be used – that approval is anticipated to occur in mid-2004.

Table 3
Washington State Classification System and Corresponding Standards for Water Bodies

Table 3.1 Marine Water Aquatic Life Uses

Parameter	Units	Extraordinary Quality	Excellent Quality	Good Quality	Fair Quality
Dissolved Oxygen 1-day minimum	mg/L	> 7.0	> 6.0	> 5.0	> 4.0
Temperature 1-day maximum	°C	≤ 13	≤ 16	≤ 19	≤ 22
pH	standard units	7.0 - 8.5 human caused variation < 0.2	7.0 - 8.5 human caused variation < 0.5		7.5 - 9.0 human caused variation < 0.5
Turbidity	NTU	≤ 5 over background turbidity when background turbidity is ≤ 50; ≤ 10% increase when background turbidity > 50	≤ 10 over background turbidity when background turbidity is ≤ 50; ≤ 20% increase when background turbidity > 50		

Table 3.2 Bacteria Criteria for Marine Water Uses

Parameter	Units	Criteria
For Primary Contact & Shellfish: Fecal coliform	colonies / 100 ml	Geomean ≤ 14; ≤ 10% > 41
For Secondary Contact: Enterococcus	colonies / 100 ml	Geomean ≤ 70; ≤ 10% > 208

Table 3.3 Freshwater Aquatic Life Uses

Parameter	Units	Char *	Core Salmon/Trout **	Non-Core Salmon/Trout ***	Salmon/Trout Rearing ****	Lakes
Dissolved Oxygen 1-day minimum saturation not to exceed 110%	mg/L	> 9.5	> 9.5	> 8.0	> 6.5	No human caused decrease > 0.2 below natural conditions
Temperature 7-day average of the daily maximum	°C	≤ 12	≤ 16	≤ 17.5	≤ 17.5	No human caused increase > 0.3 above natural conditions
pH	standard units	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5 with a human caused variation within the above range of < 0.5		
Turbidity	NTU	≤ 5 over background turbidity when background turbidity is ≤ 50; ≤ 10% increase when background turbidity > 50			≤ 10 over background turbidity when background turbidity is ≤ 50; ≤ 20% increase when background turbidity > 50	

* - no ambient sites in this category

** - station A438 in WRIA 8; no WRIA 9 stations

*** - all ambient sites not specifically mentioned

**** - stations 0305, 0307, 0309 in WRIA 9; no stations in WRIA 8

Table 3.4 Freshwater Water Contact Recreational Uses

Parameter	Units	Extraordinary Primary Contact *	Primary Contact **	Secondary Contact ***
Fecal coliform	colonies / 100 ml	Geomean ≤ 50; ≤ 10% > 100	Geomean ≤ 100; ≤ 10% > 200	Geomean ≤ 200; ≤ 10% > 400

* - station A438 in WRIA 8, no stations in WRIA 9

** - station X438 in WRIA 8, all other stations not specifically identified

*** - stations 0305, 0307, and 0309 in WRIA 9.

The water quality standards for ammonia have also changed. For marine waters the acute standard is 0.233 mg/L (un-ionized NH₃), and the chronic is 0.035 mg/L (un-ionized NH₃). A calculation based upon salinity, temperature, and pH is necessary in order to convert total ammonia concentrations to un-ionized ammonia. The freshwater standards vary depending on the presence of salmonids or other early life stage fish, and also involve a calculation based upon temperature and pH. The other toxics standards were not changed. See WAC 173-201A-240 for the detail on the ammonia standard.

When waters do not meet standards, they must be listed per the requirements of section 303(d) of the Clean Water Act. The 303(d) list is published every 3 to 5 years. The most recent list was released for public review on January 15, 2004, and a draft 2003/4 list has been proposed. Once listed, the water body must be studied and controls must be put into place that will correct conditions so that it meets standards. Controls often involve dividing the pollutant load into allocations that the water body can assimilate and still meet the standards. This process is called a Total Maximum Daily Load (TMDL). TMDLs are described in more detail in Chapter 5 of this report.

The biological, chemical, and physical parameters used to assess a water body's health under the State's classification system are fecal coliform bacteria, dissolved oxygen, temperature, pH, ammonia, turbidity, and a variety of chemical compounds. Each parameter, or indicator of health, is described below.

Bacteria

Fecal coliform and enterococcus bacteria live in the intestines of warm-blooded animals including humans, wildlife, and pets, and are used as an indicator of human fecal pollution. Most fecal coliform bacteria do not cause disease, but they may coexist with bacteria and viruses that may pose a public health risk. Because it is technically difficult and costly to distinguish whether the bacteria found in the water came from humans or from other warm-blooded animals, the usefulness of fecal coliform bacteria as a predictor of human health risk is limited. The Washington State Department of Ecology recently reviewed whether other bacteria indicators, such as *Enterococcus* or *E. coli* should be used as the State regulatory standard. No consensus on an alternative indicator was achieved. The State has proposed that fecal coliform criteria now be applied to waters used for shellfish growing and primary contact

recreation, and enterococcus will be used where the use is secondary contact recreation. EPA approval is now anticipated to occur in mid-2004. Until then the previous fecal coliform-based criteria will be used.

Dissolved Oxygen

Aquatic (water-based) plants and animals require a certain amount of dissolved oxygen (DO) in the water for respiration and basic metabolic processes. Waters that contain high amounts of DO are generally considered healthy ecosystems. DO concentrations are most important during the summer season when oxygen-depleting processes are at their peak. DO levels in waters bearing fish of the salmon family (salmonids) are very important. Salmon receive special consideration because they are an important cultural, recreational, and economic resource for the Northwest and are recognized as being in danger of extinction.

Temperature

Temperature is an important physical parameter for aquatic systems because it influences many of the chemical components of the water (e.g., DO concentration). Temperature also exerts a direct influence on the biological activity and growth and therefore ultimately the survival of aquatic organisms. Temperature levels in waters bearing fish of the salmon family (salmonids) are also very important.

pH

The pH of water is a measure of the concentration of hydrogen ions. A pH value higher than 7 (meaning there are fewer free hydrogen ions) is considered alkaline or basic, a value of 7 is considered neutral, and a value of less than 7 is considered acidic. The pH of water determines the solubility and biological availability of chemical constituents such as heavy metals and nutrients. Metals tend to be more toxic at lower pH values because they are more soluble. Likewise, at lower pH values nutrients are also in soluble form and are therefore more readily taken up by aquatic plants.

Turbidity

Turbidity refers to the amount of suspended material in water. It is measured by the amount of light scattered in a water sample and is reported in Nephelometric Turbidity Units (NTU). More material in the water results in greater light scattering and a higher NTU reading. In general, higher turbidity results from human activities within the watershed (e.g., land development and construction causing loss of vegetation, increased runoff, and increased erosion). The effects of high turbidity can include diminished light penetration for plant growth and DO production, sedimentation of gravel beds used by spawning fish, and waters that are too “dirty” to enjoy.

Usually turbidity is used to evaluate the impact of a pollutant source. Two measurements are made to measure the change in turbidity from a source: one upstream of a discharge point (background levels) and another downstream. Because King County often monitors waters where there is no identifiable pollutant source the County measures only one point in a stream

and then compares it to the average of all measurements for that site. Values exceeding the average by 5 NTU or more are considered substandard.

Other Water Quality Standards

Other water quality standards have been set for special uses, including numeric chemical-specific standards for the protection of aquatic species and human health and more judgment-based narrative standards. These standards may be developed for the water or for the subaquatic sediments.

Aquatic Health Standards

Standards to protect aquatic organisms have been developed that define acceptable levels for individual chemicals. Acute standards protect aquatic organisms from immediate and severe impacts such as death or poisoning, while chronic standards protect against sub-lethal effects such as reduced growth or reproduction.

Human Health Standards

Chemical-specific standards for water or sediment are designed to prevent harm to humans as they are transmitted to humans through the food chain.

Nutrient Standards

Ammonia is the only nutrient that has a numeric water quality criterion. The Washington State ammonia standard is based on un-ionized ammonia. However, for total ammonia, as is measured by King County, the State uses the U.S. Environmental Protection Agency's (EPA's) criteria concentrations. These total ammonia criteria are based on temperature, salinity, and pH of the water. Ammonia tends to have a seasonal cycle, as do other nutrients. Higher concentrations typically occur in summer and fall and at deeper depths, corresponding to decay of organic nitrogen from phytoplankton.

Sediment Quality Standards

In the early 1990s, Washington State became the first state to implement Sediment Quality Standards for marine waters, providing a new tool to assess the cumulative impacts of chemicals on the environment. The “standard” includes chemical-specific criteria that designate what is considered healthy sediment quality, the sediment quality standard (SQS), as well as a threshold for considering sediment remediations called the Cleanup Screening Level (CSL). When these chemical criteria are exceeded, the adverse impact is verified using toxicity testing.

Non-Regulatory Water Quality Indicators

Other measures have been developed over time based on the experience of water quality professionals. While these may not have the enforcement capabilities of regulatory standards,

they are time-honored methods to characterize water quality and to provide comparisons that guide the development of water quality protection efforts. Two indices used for freshwater assessment are: the Trophic State Index, and the Water Quality Index. In marine waters chlorophyll-*a* is used as a non-regulated indicator of phytoplankton blooms. These indicators are described further in this section.

Trophic State Index

A common way to characterize the health of lakes is by the numerical Trophic State Index (TSI). With the TSI, lakes can be rated and compared according to the level of biological activity (e.g., level of nutrients, algal growth, and so forth). This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, and so forth) represents a doubling of algal biomass and is related to nutrients and transparency (water clarity). The summer mean values of the three most common lake parameters—Secchi depth transparency, total phosphorus, and chlorophyll-*a* concentrations—are used to develop the TSI. The calculated TSI values provide three ranges of lake classification—oligotrophic, mesotrophic, and eutrophic—as shown in Table 4.

Table 4
Average Summer (June-September) Trophic State Index Values

TSI Value	Classification	Characterization
< 40	Oligotrophic	Low biological productivity resulting in high water clarity, low algal levels, and low phosphorus concentrations
40–50	Mesotrophic	Moderate levels of plant and animal activity, resulting in moderate water clarity, moderate, algal levels, and low phosphorus concentrations
> 50	Eutrophic	High biological productivity resulting in low water clarity, high algal levels, and high phosphorus concentrations

Secchi Depth Transparency

Secchi depth transparency is a measure of water clarity or transparency as measured by viewing a Secchi disk—an 8-inch disk for fresh water or a 12-inch disk for marine water, with alternating black and white quadrants. The disk is lowered into the water until the observer can no longer see it. This depth of disappearance, called the Secchi depth, is a measure of the water's transparency. Algae, soil particles, and other materials suspended in the water affect transparency. The Secchi depth will decrease as these factors increase. In King County, clarity tends to be lower during periods of high algal growth (spring and summer) and during periods of high stormwater flows (winter).

Phosphorus

A certain amount of nutrients such as nitrogen, phosphorus, and silica are necessary for plant and animal growth. An excessive amount of nutrients, however, can increase the growth of aquatic plants, which subsequently decay and deplete oxygen to levels incapable of sustaining aquatic organisms. Phosphorus is the primary nutrient of concern in freshwater systems because, if present in excess amounts, it can cause nuisance algal blooms or, on occasion, toxic

algal blooms. Phosphorus enters water bodies via discharge of detergents, runoff containing fertilizers, or seepage from failing septic systems. Sediment can also be a source of phosphorus, as phosphorus readily binds to soil particles and is washed into the lakes. Phosphorus is later released into the water column when DO concentrations fall below 0.2 mg/L.

Chlorophyll-*a*

Chlorophyll is the green pigment in plants that allows them to create energy from light (photosynthesis). Chlorophyll serves as an indirect measure of the amount of plants/algae in the water column. Chlorophyll-*a* is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Water Quality Index

The Draft Water Quality Index (WQI) was established by Ecology in 2002³ as a means to rank the conditions of streams. The WQI integrates a series of key water quality parameters into a single number that can be used for comparison over time and between locations. King County has modified the WQI slightly to achieve a better representation of its rivers and streams.

The WQI is a unit-less number ranging from 10 to 100; a higher number indicates better water quality. For temperature, pH, fecal coliform bacteria, and DO, the index expresses results relative to levels required to maintain beneficial uses (based on State standards). There are no State standards for nutrient and sediment measures. Instead, they are expressed relative to expected conditions in a given ecoregion. Multiple constituents are combined and results aggregated over time to produce a single score for each sampling station. In general, stations with scores of 80 and above meet expectations for water quality and are of “low concern,” stations with scores of 49 to 80 indicate “moderate concern,” and stations with scores below 40 do not meet expectations and are of “high concern.”

Chlorophyll-*a* (Phytoplankton Blooms)

In marine waters, as in the freshwater Trophic State Index described above, chlorophyll-*a* concentrations are used as the best available indicator of phytoplankton biomass because planktonic algae contain this photosynthetic pigment. Although not an exact measurement, high chlorophyll-*a* concentrations are useful for evaluating the presence and frequency of phytoplankton blooms. An increased frequency of phytoplankton blooms on a yearly basis serves as an indicator of possible nutrient excess and potential water quality problems.

Ongoing Monitoring Programs

Ensuring the health of county water bodies, and so the health of the people using them, is the purpose of King County’s water quality efforts. The County’s extensive water monitoring programs provide the high quality data from which decisions can be made to direct these efforts.

³ Hallock, D. 2002. *Washington’s Water Quality Index*. Draft report prepared for the Washington State Department of Ecology.

Monitoring programs are also designed to protect the significant investment in water quality improvements made by the people of King County. Though nearly all wastewater is now either treated with an onsite septic system or sent to treatment plants, water quality monitoring is still an important tool to help ensure continued wastewater system integrity and to identify any threats to the gains we have already made to improve water quality. King County regularly assesses the impact of its own operations by measuring the quality of the effluent from each of its wastewater treatment facilities, the surrounding water, and nearby beaches to ensure the facility is meeting regulatory requirements. A summary of the monitoring programs is shown in Table 5; a map of monitoring locations, also known as stations, is included as Figure 7. The table and map also include information on special studies, described later in this chapter.

King County's laboratories support the monitoring programs. The system includes three process laboratories—one at each treatment plant (South, Vashon and West Point)—and an environmental laboratory located centrally in metropolitan Seattle. The process laboratories perform conventional chemistry and microbiology analyses in support of plant process optimization and NPDES requirements. The process laboratories also provide support to capital projects such as effluent reuse and the advanced wastewater technology (AWT) program. The environmental laboratory provides support for NPDES permit requirements, the biosolids source control program, the CSO control program, and the lakes, streams and marine monitoring programs.

Additional information and data are available on the County's web sites listed in Appendix B.

Ambient Monitoring

Ambient refers to the general, routine monitoring of a waterbody, without singling out specific pollutant sources. Ambient monitoring stations are located in lakes and streams and in the Puget Sound to monitor the long-term environmental quality of these waters.

The objectives of ambient monitoring programs are as follows:

- Assess existing conditions for waterbodies, determine if Washington State Water Quality Standards are met, and track progress in correction of 303(d) listed parameters
- Determine long-term water quality trends for King County waters
- Identify successes in water quality protection, and make recommendations for future efforts
- Provide comparison for data collected near King County outfalls
- Monitor the integrity of the wastewater conveyance system and track water quality parameters of interest to the Wastewater Treatment Division (WTD)
- Provide information on historical and existing conditions in support of special projects such as the Sammamish/Washington Analysis and Modeling Program (SWAMP) and the WTD Habitat Conservation Plan

Freshwater Ambient Monitoring

Freshwater ambient monitoring programs run by King County include the Major Lakes, Small Lakes, Swimming Beach, and Stream Monitoring Programs.

Each of the lakes has one or more sampling stations located in its deep central basin where the influence of the shoreline is muted by the mixing action of wind and waves. Changes observed over time at these sites reflect broad large-scale or landscape-scale changes in the watershed and the lake. Other sampling stations are distributed around the shoreline of the lake, primarily off the mouths of inflowing streams. Changes in water quality at these stations are more directly influenced by shoreline activities and by the quality and quantity of inflowing stream water.

Streams and rivers in the King County service area are monitored if they cross sewer trunk lines or if they are considered a potential or significant source of pollutant loading to a major water body. Monthly baseflow samples have been collected along some of the tributaries flowing into Lake Washington, Lake Sammamish, and the Green River system since 1979. Beginning in 1987, storm-influenced samples have been collected to increase our understanding of wet weather impacts on local water quality.

Every summer since 1996, swimming beaches on Lake Sammamish, Lake Washington, and Green Lake have been surveyed to determine levels of bacterial pollution. King County evaluates relative human health risks and necessity for beach closures in cooperation with the Seattle-King County Public Health Department and local parks departments.

Small Lakes

Over 100 Volunteer Lake Monitors serve as the eyes and ears of the Lake Stewardship Program, alerting staff to problems and interesting events on their individual lakes. 48 Lakes receive a full battery of monitoring from these volunteers. Information on lake level, water quality, and aquatic plants helps the County better understand how individual lakes work and how best to preserve their quality. Lake monitoring results are used to:

- Gather baseline data;
- Assess long-term trends;
- Estimate seasonal or water column variability;
- Identify problems and propose management solutions; and
- Educate and provide long-term stewardship opportunities.

Data collected by volunteers is reported informally in King County's quarterly newsletter, *The Lake Steward*, and formally in the annual *Lake Monitoring Report*.

Table 5
Summary of King County Water Quality Monitoring Programs

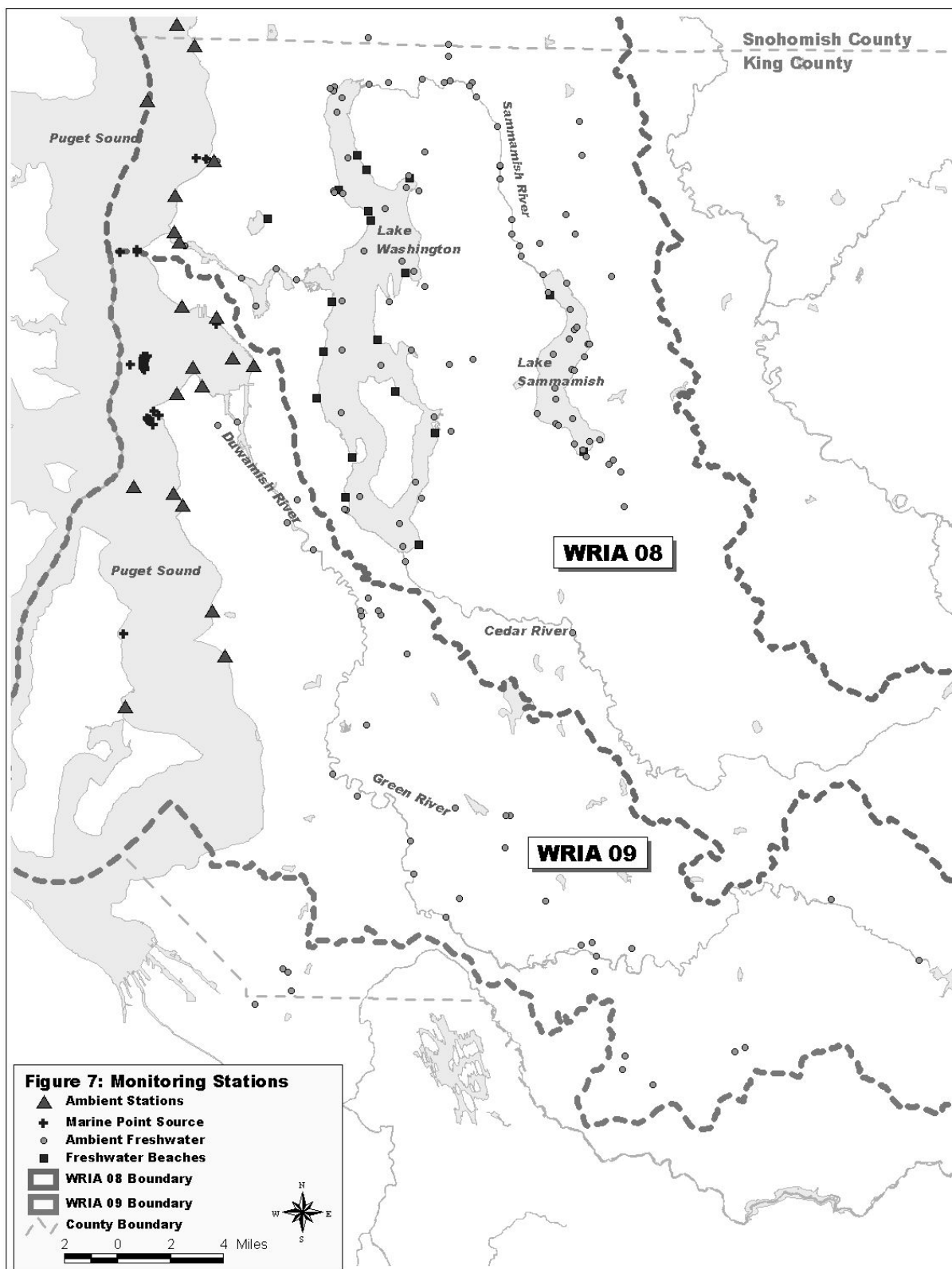
Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Ambient Monitoring						
Marine monitoring	Water and sediments in areas of Puget Sound away from outfalls and CSOs; shellfish and algae ifrom Puget Sound beaches	Water samples: temp, salinity, clarity, DO, nutrients, chlorophyll, and bacteria Beach sediment: grain size, solids, TOC, metals, and organic compounds Shellfish: lipids, bacteria, metals, and organic compounds Macroalgae samples: metals	Water samples at outfalls: collected at multiple depths, ranging from 1 to 200 m Sediments, shellfish, and algae: from single sites	Water samples : monthly Beach sediment: annually Shellfish & Macroalgae: annually	Voluntary—to assess potential effects to water quality from nonpoint pollution sources and to compare quality against point source data	Ongoing
Major lakes monitoring	Cedar-Sammamish Watershed (WRIA 08) only: Lakes Washington, Sammamish, and Union	Temperature, DO, pH, conductivity, clarity, phosphorus, nitrogen, and fecal coliform	Samples collected every 5 m from 1 m below the surface to near the lake center bottom and around the shoreline	Biweekly during the growing season; monthly during the rest of the year	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of lakes	Ongoing
Small lakes monitoring	48 small lakes within King County are monitored by volunteers	Precipitation, lake level, temperature, Secchi depth, phosphorus, nitrogen, chlorophyl-a, phytoplankton	Single point and vertical profiles	Daily rainfall & lake level, weekly temperature & Secchi depth, rest every 2 weeks April to October	Voluntary – to characterize and identify trends in water quality	Ongoing
Rivers and streams monitoring	Rivers and streams of both watersheds; emphasis on those that cross wastewater conveyance lines or that could be a source of pollution	Baseflow and storm samples: Turbidity, TSS, pH, temperature, conductivity, DO, nutrients, ammonia, bacteria Storm samples: trace metals	Various	Monthly sampling under baseflow conditions Three to six times per year at mouth of streams under storm conditions	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of streams and rivers	Ongoing
Swimming beach monitoring	Cedar-Sammamish Watershed: Lake Washington, Lake Sammamish, and Green Lake	Bacteria		Summer	Voluntary—to evaluate human health risks and necessity for beach closures	Ongoing
Benthic macroinvertebrate monitoring	Wade-able stream sub-basins (Intensive studies also being done under SWAMP and G-DWQA.)	Size and distribution of aquatic macroinvertebrate populations	Surber sampling	Yearly	Voluntary—to establish a baseline for identifying long-term trends	Ongoing
Wastewater Plant Outfall Monitoring						
Marine wastewater plant outfall water column and beach monitoring	Water in Puget Sound near treatment plant outfalls and the Denny Way CSO; sediment, shellfish and algae at beaches near outfalls	Same parameters as in the marine ambient monitoring program	Water samples at outfalls: collected at multiple depths, ranging from 1 to 150 m	Water samples : monthly Beach sediment: annually Shellfish & Macroalgae: annually	Voluntary—to assess potential effects to water quality from wastewater discharges	Ongoing
Marine NPDES sediment monitoring	Sediments in Puget Sound near treatment plant outfalls and the Denny Way CSO	Sediment samples at outfalls: grain size, solids, sulfides, ammonia-nitrogen, oil & grease, TOC, metals, organic compounds, and (at South and West Point) benthic infauna	Sediment samples in a grid pattern as defined in the Sampling & Analysis Plan, approved by Ecology	Sediment samples at outfalls once per permit cycle	NPDES permit requirement	Ongoing

Table 5
Summary of King County Water Quality Monitoring Programs (continued)

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Special Studies						
Sammamish-Washington Analysis and Modeling Project (SWAMP)	Water and sediments in major lakes—and their inflowing streams	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Various	Intensive	Voluntary—to develop a computer model of the watershed	Complete by 2005
Remote underwater sampling station	Lakes Washington and Sammamish	Water quality data	Automatic sample collection via five robotic buoys	24 hours a day, 365 days a year		Ongoing
Small Stream Toxicity/Pesticide Study	“Selected” small streams	Pesticides & other toxic chemicals	Various	Intensive		Ongoing
Green-Duwamish Water Quality Assessment (G-DWQA)	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Broad spectrum of water quantity and quality, biological, and physical parameters	Various	Intensive	Voluntary—to develop models, evaluate BMPs, prepare risk assessments	Complete in 2006
Storm Impact Water Quality Monitoring	Water in Green and Duwamish Rivers—and their inflowing rivers and streams—under storm flow conditions	Broad spectrum of water quantity and quality, sediment quality, biological and physical parameters	Various	Intensive	Voluntary – to evaluate conditions, support modeling and WRIA planning	Completed in 2003
Temperature and DO Studies	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Daily fluctuations in temperature and DO, especially in the summer	Continuously recording data loggers	Intensive	Voluntary - to evaluate conditions, support modeling and WRIA planning	Completed in 2003
Microbial Source-Tracking Study	Water	Land uses and bacterial sources associated with bacterial populations		Intensive	Voluntary – assist in setting & measuring TMDLs	Complete early 2004
Salmonid Habitat and Inventory Assessments	Habitat	Quantification of conditions that contribute to high quality aquatic habitat	Observation	Intensive	Voluntary—to identify areas needing habitat restoration	
Brightwater Outfall Studies (wastewater capital project)	Water, sediment & eel grass for the preferred Brightwater outfall site Upland soils at outfall portal 19	Water quality: temperature, salinity, dissolved oxygen, nutrients, and fluorescence Sediments: borings for chemicals Upland soils: total petroleum hydrocarbons, lead, and volatiles	Water column samples and continuous buoy readings Borings Soil samples Eel grass diver survey	Intensive	Voluntary--to support the design of the Brightwater Outfall	Complete in 2010
Brightwater Surface Water Characterization (wastewater capital project)	Water samples of surface runoff from Route 9 site, and Little Bear Creek upstream and downstream of site.	Temperature, pH, dissolved oxygen, and specific conductance, Alkalinity, biochemical oxygen demand (BOD), total dissolved solids, total suspended solids, and turbidity	Auto-samplers for synchronized water column sampling	Intensive	Voluntary to support permitting of the Brightwater plant	Complete end of 2004
Norfolk post-remediation sediment monitoring (wastewater capital project)	Sediment near the Norfolk CSO on the Duwamish River	Chemicals	Sediment samples per approved SAP	Intensive	Regulatory—under a 1991 Consent Decree	Complete in 2004
Denny pre-construction sediment monitoring (wastewater capital project)	Sediment near the Denny Way and Lake Union CSOs	Benthic communities	Sediment samples per approved SAP	Intensive	Regulatory—under a NOAA Fisheries Section 7 ESA consultation	Post-construction
Diagonal/Duwamish Remediation Dredging Monitoring (wastewater capital project)	Sediments off of the Seattle Diagonal stormdrain (includes City and County CSO) and the County’s Duwamish CSO.	Sediment chemistry, turbidity, cap surveys	Sediment samples per approved SAP	Intensive	Regulatory—under an EPA/Ecology Order	Post construction through 2013

DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; BMP = best management practice; RSD = Ronald Sewer District; SAP = sampling and analysis plan.

Figure 7
King County Monitoring Stations



Marine Ambient Monitoring

Marine ambient monitoring is conducted in areas away from the influence of outfall or other point source discharges to provide valuable background and comparison data. The program includes water and sediment monitoring as well as shellfish and macroalgae monitoring at selected beaches. Water column monitoring is an important component of the marine monitoring program and is structured to detect natural seasonal variations in the water column and to identify changes influenced by human activities. Temperature and salinity influence the amount of water column stratification, which in turn can influence the amount of pollutants trapped within the water column. Sediment monitoring is included in the marine monitoring program because many pollutants tend to settle onto bottom sediments. At sufficient concentrations, these pollutants may be harmful to organisms that live in or on the sediments (benthic organisms) and may then also accumulate up through the food chain.

Benthic Macroinvertebrate Monitoring

One of the ways to assess the health of a waterbody is to compare the resident plants and animals to those in a similar water body that is known to be healthy. If the plants and animals are the same types and proportions and of similar number and density, it can be inferred that the studied water body is also healthy. The primary purpose of Benthic Macroinvertebrate Monitoring Program is to characterize the size and distribution of aquatic sediment-dwelling macroinvertebrate (insect) populations in King County watersheds. These data collected over time in the ambient monitoring programs will be used to detect any long-term population trends. Additional intense monitoring will attempt to determine the health of macroinvertebrates in wade-able stream sub-basins within the Cedar-Sammamish watershed (WRIA 08) and the Green-Duwamish watershed (WRIA 09) (See “Special Studies” later in this chapter.).

Benthic macroinvertebrates have been monitored under two distinct programs within the County’s Water and Land Resources Division (WLRD). The wastewater related benthic monitoring program was initiated in the mid-1970s. The primary objective was to monitor streams potentially impacted by wastewater, treated effluent, and the system of pipes and pumps that make up the collection and transfer system. This program was part of the ambient water quality monitoring program that includes lakes and mainstem rivers. In the early to mid 1990s a second macroinvertebrate monitoring program began to provide data to evaluate the success of recent basin planning efforts and, when possible, to make specific recommendations for improved watershed management. These two programs were designed to address different, but closely related and complementary water quality issues. These programs are now combined in the County’s consolidated freshwater monitoring program.

The objectives of the Freshwater Streams Benthic Macroinvertebrate Monitoring Program are as follows:

- Determine existing aquatic macroinvertebrate conditions of wade-able stream sub-basins located within WRIA 08 and WRIA 09
- Identify differences in macroinvertebrate communities in the WRIA 08 and WRIA 09 watershed sub-basins

- Collect data that can be used as a baseline tool for detecting long-term trends in benthic macroinvertebrate communities

Marine Wastewater Plant Outfall Monitoring

For over 30 years, an extensive outfall monitoring program has been in effect to assess water quality around the marine outfalls for the County's wastewater treatment facilities.

Outfall monitoring is now focused around the County's three secondary wastewater treatment plants, two combined sewer overflow (CSO) treatment plants, and the Denny Way CSO (the County's largest CSO). The program consists of water column and sediment monitoring, as well as shellfish and algae monitoring at beaches near the outfalls. A variety of parameters are analyzed, including bacteria, oxygen, and nutrients in the water column and metals and organics in sediments and tissues.

Receiving water monitoring at the outfalls backs up other precautions taken to assure that plant operations are not adversely impacting water quality. For example, prior to discharge effluents are disinfected, continuously monitored for chlorine residual levels, and then analyzed for bacteria at regular intervals as verification that the treatment process is effective.

Sediment monitoring at the outfalls is required under the County's NPDES permits. Ecology and the County are working to reach agreement on a scope of work for sampling design for the next phase of sediment monitoring activities. This will be finalized in the Sampling and Analysis Plan that will be prepared for sampling at each treatment plant outfall.

Beach (intertidal) areas that are in the vicinity of the treatment facility outfalls are also monitored for a variety of parameters to assess whether discharges may be affecting beach areas. Shellfish (butter clams), sediments and macroalgae samples are collected as part of the beach assessment.

Special Studies

When ambient monitoring suggests the early stages of degrading water quality or when decisions must be made based on scientific information, King County initiates special studies to understand the situation and to project outcomes of different actions. The information from the ongoing monitoring programs often must be supplemented with information from more intense and focused sampling and/or greater analytical precision. These special studies are usually intensive in scope, but limited in time. Currently, there are two major projects—the Green-Duwamish Water Quality Assessment (G-DWQA) and the Sammamish-Washington Analysis and Modeling Project (SWAMP). There are also several smaller projects under way. Monitoring projects for the Marine Outfall Siting Study (MOSS) to assist in siting the new Brightwater Treatment System marine outfall were completed in 2003. There are current ongoing special studies to support water quality monitoring and to assist in the outfall diffuser design prior to outfall construction.

A summary of these studies is shown in Table 5; a map of sampling locations is included as Figure 7. The table and map also provide information on ongoing monitoring programs,

described earlier in this chapter. The details of these complex projects can be found at the County Web sites listed in Appendix B.

Green-Duwamish Watershed Water Quality Assessment

The primary goal of this project is to develop analytical tools for evaluating current and future water quality issues in the Green-Duwamish watershed. It will provide water quality information to a variety of clients internal and external to King County DNRP by collecting water quality information, developing a watershed model, and using the model to explore resource management options. The project will also assist wastewater capital planning (including the CSO program and the Habitat Conservation Plan). Specifically, the project will accomplish the following:

- Assess existing and projected water quality conditions for selected parameters, and assess the efficacy of best management practices for achieving Washington State Water Quality Standards in the Green-Duwamish watershed
- Coordinate with Ecology in order to provide technical information for Ecology's TMDL development for stakeholders of the watershed to use to achieve the most cost effective improvement in water quality in the watershed
- Assess parameters of interest for the King County WTD
- Provide information to support the WTD's Habitat Conservation Plan (HCP) and WRIA 09 salmon conservation planning efforts, including information on water quality as a factor of decline for salmonids

The G-DWQA will involve water quality and hydrologic monitoring, loadings calculations and land use analysis, land use/land cover modeling, water quality and quantity modeling, microbial source-tracking, and ecological risk assessment. It is scheduled to be complete in 2006.

Important components of the G-DWQA—storm impact water quality monitoring, loadings and land use analysis, microbial source-tracking, and temperature and DO studies—are described in the following sections.

Storm Impact Water Quality Monitoring

An intensive monitoring program was developed for the G-DWQA to achieve the following objectives:

- Measure instream water quality parameter concentrations in different geographic areas of the watershed throughout the year, including mouths of major tributaries and boundary conditions of the Green River mainstem
- Measure instream water quality parameter concentrations resulting from different land use/land cover types within the stream drainage area
- Measure in-stream water quality parameter concentrations as a function of the rise, peak, and fall of the corresponding stream hydrograph to determine peak concentrations and variability within a storm-influenced flow

- Collect sufficient data to allow development and calibration of water quality models for the Green River watershed

The program was initiated in 2001 and completed in December 2003. Both storm-influenced and baseflow samples were being collected from 17 stations distributed throughout the Green-Duwamish watershed. Some of these stations overlap with the ambient stations monitored in the past in order to provide historical continuity.

Loadings Calculations and Land Use Analysis

Total loadings (as mass/time) for each water quality parameter will be calculated for the water quality parameters monitored in the program described above. Total loadings will be estimated using measured Event Mean Concentrations (EMCs) and the average discharge for the interval represented by the sample. Probabilistic techniques, such as Monte Carlo simulations, may be used to further define how the underlying distributions of discharge and concentration affect the overall results. Probabilistic techniques may also be used when only one sample is collected per storm at a particular sampling site. Alternative approaches to calculating loads (e.g., ratio estimators or regression estimators) may be used as well, depending on the nature of the data and analysis objective.

Loading estimates will be established either on an annual basis (kg/ha/year) or on a storm basis (mg/L). The loading estimates will be based on water quality data generated for this project, as well as through a literature review of loading estimates, for the identified land use/land cover classifications. The loading estimate approach may include one or more of the following methods:

- Assignment and/or calibration of loading factors to specific land uses based on project water quality data from the most representative locations.
- Assignment and/or calibration of loading factors to sub-basins based on water quality data from those sub-basins.
- Assignment and/or calibration of loading factors for different types of land uses based on literature values.
- Analysis of possible storm event hydrological characteristics to determine predictive relationships to storm event loads.
- Development of correction factors for buffering effects (e.g., land use/cover within 100, 200, and/or 300 meters of water bodies in comparison to the land use/cover within the overall catchment area.)
- Determine and identify level of significance of the relationship between proximity of land use/cover within the respective drainage area to the sampling point, outside of the buffers specified in the preceding bullet.
- Normalization between land use data provided by DNRP (e.g., LandSat imagery, other imagery, categorizations based on imagery) and watershed modeling categories (also provided by DNRP).

Temperature and Dissolved Oxygen Studies

To supplement the information collected in the freshwater ambient monitoring programs, an intense temperature and DO sampling program was implemented under the G-DWQA. Both

programs use continuously recording data loggers to characterize the daily fluctuations in temperature and DO. Final reports describing methods, results and recommendations will be completed in the first quarter of 2004.

Microbial Source-Tracking Study (G-D WQA)

A preliminary review of a small portion of Green-Duwamish water quality data collected during storm events in 2001 and 2002 generally shows that loadings and concentrations of Fecal Coliform, *E. coli* and *Enterococcus* increase and decrease with storm flows. This result suggests that bacterial concentrations and loadings are related to precipitation and flows. However, since no clear quantitative relationship between flow-related variables and bacterial concentrations has been established to date other unidentified factors may also be associated with variation in bacterial concentrations in the Green River watershed. Microbial Source-Tracking (MST) is being used to investigate the relationship between bacterial sources and land use in the Green River and tributaries.

Land use may be one of the primary factors determining the specific types and sources of bacterial loadings. Land use and cover types may be useful as a surrogate to predict these sources. Sources that may be related to land use include agricultural animals (pasture and agricultural land), septic systems (rural residential), pets (suburban areas) and wildlife/birds (forested and rural areas). In order to elucidate these potential relationships, it is necessary to identify the sources of bacteria in the Green River and its tributaries and correlate them to land uses. This goal can be accomplished by microbial source tracking (MST).

Further, MST can be used to assist in setting, and evaluating progress in achieving, TMDLs for fecal coliforms in the mainstem reaches and streams that are on the 303(d) list. Affected creeks include Newaukum, Springbrook and Soos (Ecology 2002). Finally, an improved understanding of the relevance of bacterial concentrations to human health and ecological conditions in the watershed is needed. The present microbial source tracking study will collect information on bacterial sources and land uses associated with bacterial populations. This will provide baseline information that may be used to focus future studies to address the human health and ecological implications.

Sampling began in January 2003 and will complete early in 2004. The final report will be issued in mid-2005.

Salmonid Habitat and Inventory Assessments

Stream salmonid habitat assessments were implemented by King County in 1999 to quantify the instream, riparian, and watershed conditions that contribute to high quality aquatic habitat. Stream habitat evaluation is a core element of several recently implemented regional programs. The information gathered in the assessments is used to assist in the identification of areas that require stream habitat restoration and preservation for the WRIA planning process, the Sammamish River Ecosystem Restoration Study, and other land use planning and Sensitive Area regulation.

The Sammamish-Washington Analysis and Modeling Project

The Sammamish-Washington Analysis and Modeling Project (SWAMP) is a coordinated water quantity and quality monitoring and modeling project that will support future water resource decisions for King County's fresh waters in the Cedar-Sammamish watershed. The overall objectives of SWAMP are as follows:

- Identify risks to aquatic life (including threatened and endangered species), wildlife, and people under existing conditions.
- Project future water body conditions and risks under a variety of possible future land use scenarios
- Provide support to resource management programs including:
 - Salmon conservation and recovery efforts in the watershed
 - Planning for use of reclaimed water in the watershed
 - Ecology's Total Maximum Daily Load (TMDL) program
 - WTD's HCP
- Provide an organized database and integrated modeling framework to address water resource issues in the watershed

The major component of this project is development of a computer model for Lake Washington, Lake Sammamish, and Lake Union and their inflowing rivers and streams. Coupled with these models will be a broader watershed model that simulates streamflow and water quality based on historical, current, and future land use scenarios in King County watersheds. SWAMP is directly linked and coordinated with current King County water resource monitoring efforts. This project will be completed in 2005.

Three components of SWAMP—the sediment study, remote underwater sampling station, risk assessment, and Small Streams Toxicity/Pesticide Study—are described in the following sections.

Sediment Study

As part of SWAMP, King County completed a comprehensive sediment sampling study for Lakes Sammamish, Washington, and Union. There were four primary objectives of the study:

- Conduct a baseline sediment quality evaluation including both chemical and biological testing;
- Evaluate the relative distribution of potential contaminants of concern;
- Evaluate sediment toxicity; and
- Evaluate benthic community structure and compare these data with sediment toxicity testing.

Remote Underwater Sampling Station™

In July 2000 as part of SWAMP, King County installed five robotic buoys to collect water quality data from Lake Washington and Lake Sammamish. The buoys collect water samples automatically, 24 hours a day, 365 days a year. Data are transmitted daily to King County. The data from the buoys will contribute to the development of the models discussed above.

Swamp Risk Assessment

As part of SWAMP, King County DNRP is in the process of conducting an Ecological and Human Health Risk Assessment. The risk assessment (RA) consists of three tiers. The first tier consists of a general ecological and human health screening of all available existing water, sediment and tissue data. The screen consists of comparing chemical data to effect thresholds, below which adverse effects (i.e., risk) are not anticipated. The results of this part of the RA provide a means to focus our efforts on specific areas and chemicals that are of greatest concern.

Tier 2 includes a spatial evaluation of the chemicals identified in Tier 1 as posing possible risk, in addition to a more detailed assessment of exposure. This will result in identification of chemical specific concerns within individual water bodies. A Human Use Survey was conducted within the study area to provide more realistic exposure estimates for the human health component of the RA. The survey identified areas within the study area where the greatest recreational use (e.g., fishing, swimming, beach play etc.), and therefore the greatest exposure to chemicals of concern, occurs.

For Tier 3, probabilistic risk assessment techniques will be used to further evaluate any potential risk identified in Tier 2. Probabilistic assessments use distributions of species sensitivity combined with distribution of exposure concentrations to better describe the likelihood of exceeding an effects threshold, and thus risk of adverse effects. Due to data availability, probabilistic techniques may only be used for the aquatic and wildlife components of the RA. The results of Tier 3 will be combined with additional physical and biological data to further evaluate potential risk. This “line of evidence approach” will be used to evaluate additional data and provide a more watershed-based approach to the overall RA. The line of evidence assessment will include an evaluation of a number of ecological indices including the benthic index of biotic integrity (B-IBI), water quality index, sediment quality index, habitat index, and fish index. In addition, toxicity test data will also be included in the line of evidence approach. These data will be presented spatially using a GIS format.

Future work will include an assessment of future potential risk for a select group of stressors. This part of the assessment will use data generated by the water quality and quantity models being developed as part of SWAMP.

Small Streams Toxicity/Pesticide Study

The Small Streams Toxicity/Pesticide Study is being done under SWAMP and is intended to assess the presence and biological implications of pesticides in selected small streams in the watershed. This four-year study was begun as a follow-up to recent studies that detected pesticides in regional stormwater runoff and surface waters.⁴ These studies indicated that small

⁴ Davis, D. Washington State Pesticide Monitoring Program reports: Publications 93-e09 (1993), 96-305 (1996), 98-305 (1998), 00-03-003 (2000).

urban and suburban streams may contain high concentrations of a wide variety of pesticides during storm runoff periods. This finding led to the hypothesis that chemicals applied to lawns and landscapes are making their way into the aquatic environment through nonpoint runoff. Many of the pesticides present in these streams do not have Water Quality Standards or guidelines, leaving a gap in our understanding of the ecological consequences of these pesticides to aquatic life in these streams. This study will fill some of that gap.

Wastewater Capital Project Monitoring

Monitoring is done in support of capital project siting, permitting and construction. Usually the monitoring involves pre-construction baseline characterization followed by post-construction monitoring to identify project effectiveness and continued integrity.

Brightwater Outfall Studies

Studies for the Brightwater marine outfall began in October 1998 (under the former program title Marine Outfall Siting Study) to assist with siting and design of a marine outfall for the new Brightwater Treatment Plant. The sampling program has included the following major study components: oceanography, submarine geophysics, water column sampling, beach water quality sampling, sediment sampling, and biological surveys.

In 2003, water column and beach water quality sampling continued at the selected outfall zone off of Point Wells along King County's northwest shoreline. Sediment borings were collected from the surface down to a depth of 35 feet and analyzed for an extensive list of chemical parameters. Parameters under the Washington State Sediment Management Standards, Puget Sound Dredge Disposal Analysis Program, and the upland disposal water characterization program were analyzed. Upland soil borings were collected at outfall portal 19 and analyzed for total petroleum hydrocarbons, lead, and volatiles. In August 2003 an autonomous monitoring buoy was deployed close to where the end of the outfall will be placed. The buoy contains instruments that profile the water column at a minimum of twice a day for a variety of parameters, including dissolved oxygen, nutrients, salinity, temperature, and fluorescence. The buoy will remain in place for an entire year. And lastly, an eelgrass distribution survey was conducted along the preferred outfall alignment to obtain detailed information that will allow the outfall to be constructed with minimum disturbance to eelgrass habitat.

Brightwater Surface Water Initial Characterization

The primary goal of the Brightwater Route 9 Monitoring project is to provide water quality and quantity information in the vicinity of the preferred Brightwater Route 9 treatment plant site. The scope of work includes water quality and hydrologic monitoring for the following objectives:

- Provide data on parameters that affect fish species in the local basin.

Voss, F., and Embry, S. 2000. *Pesticides detected in urban streams during rainstorms in King and Snohomish Counties, Washington, 1998*. USGS Water Resources Investigations Report 00-4098.

Voss, F., Embry, S., Ebbert, J., Davis, D., Frahm, A., and Perry, G. 1999. *Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington*. USGS Fact Sheet 097-99.

- Establish baseline data on the current quality of site runoff from the preferred Brightwater Route 9 treatment plant site; and
- Provide information that will be used in the future for comparison to Brightwater construction and operating conditions in the local basin.

In order to evaluate the effects of the proposed Route 9 site development, water quality measurements need to identify the quality of waters leaving the site as well as characterize Little Bear Creek upstream and downstream of the site. Auto-samplers will be located at each of the monitoring stations and activated such that collections will begin near the same time depending on surface water runoff response. Water quality parameters to be analyzed for this project can be grouped into two general categories:

- Conventional – Alkalinity, biochemical oxygen demand (BOD), total dissolved solids, total suspended solids, and turbidity
- In-stream parameters – Temperature, pH, dissolved oxygen, and specific conductance.

Sampling began in October 2003 in an attempt to capture low flow conditions prior to the start of our normal wet season (typically October through May). Sampling will continue through part of the next wet season ending in December 2004, with the intention that the years and analytes will be expanded.

Denny Way/Lake Union CSO Control Project: Pre-Remediation Sediment Characterization Study

The Denny Way/Lake Union CSO Control Project is a joint effort between King County's WTD and Seattle Public Utilities to control City and County CSO discharges into Lake Union and the Denny Way CSO into Elliott Bay. Monitoring to characterize the sediments was done end of 2003 and early 2004 in anticipation of the remediation that will be done when the CSO control project is completed in 2005.

Norfolk CSO Sediment Post-Remediation Monitoring

Sediment remediation at the Norfolk CSO site was undertaken in response to a 1991 Consent Decree, which defined the terms of a natural resources damage agreement between King County and the City of Seattle and federal, state, and tribal natural resources trustees. The Norfolk CSO site was chosen by the oversight group—the Elliott Bay/Duwamish Restoration Program (EBDRP)—as one of four sites prioritized for potential sediment remediation.

Chemicals of concern at the site included mercury, 1,4-dichlorobenzene, bis (2-ethylhexyl) phthalate, and PCBs, all present at concentrations exceeding CSL chemical criteria. PCB “hot spot” concentrations at the site also exceeded Toxic Substances Control Act limits for hazardous waste disposal.

Site remediation was completed in late March 1999. Remedial activities consisted of dredging and disposal of contaminated sediment and backfilling the dredged area to original grade with clean sediment from the Duwamish River Turning Basin. Contaminated sediments were removed from the site by mechanical dredge and dewatered on shore in a containment area.

Under the site hydraulic permit, issued by the Washington State Department of Fish and Wildlife, a five-year post-remediation monitoring plan is being implemented to assess cap stability and possible recontamination over time. This monitoring will be completed in 2004.

Diagonal/Duwamish Remediation Dredging

An early action project under the response to the Superfund listing of the Lower Duwamish River is remediation of the areas off of Seattle's Diagonal stormdrain and the County's Duwamish Pump Station CSO. The Diagonal drain is a shared outfall for City stormwater and CSO discharges, the past County Hanford #1 CSO discharges and current County discharges from Hanford at Rainier, Bayview North and Bayview South CSOs. The remediation is another joint project between the County, Seattle and EBDP.

The remediation alternative chosen was dredging of the contaminated sediments and capping with clean sediments. To support the dredging process several monitoring efforts are underway and planned. Characterization of the sediments has been done to satisfy requirements for safe disposal. Sampling is being conducted to address site conditions in the Duwamish River before, during and after the dredging. The purpose of this sampling is to monitor for any spread of the contaminated sediments and compliance with water quality standards during dredging, and to document final improvement over original conditions. Water column samples taken during dredging showed that the chemicals of concern were found in low concentrations, and were below any existing water quality standards (mercury and PCBs).

The capping will be complete in early 2004. A 10-year post-remediation monitoring program will then begin to document cap stability along with any chemical recontamination of the cap surface.

Other Regional Water Quality Programs

Other entities within King County conduct monitoring and water quality protection programs. King County makes an effort to keep informed of this work, coordinate efforts for complementary results, and to negotiate joint work where interests overlap. Programs are as follows:

- Ecology runs both a sediment and water monitoring program with sites located within King County. None of King County's stations overlap with Ecology's stations. Both agencies review the other's data to gain a more comprehensive picture of water quality.
- The Washington State Department of Fish and Wildlife (WDFW) collect fish samples within King County waters and analyze them for chemical contaminants. King County reviews and uses these data as appropriate.
- The U.S. Geological Survey (USGS) performed stream monitoring for the presence or absence of pesticides. King County has built upon this program in a cooperative effort.
- The USGS conducted water quality sampling within the Green River watershed. This data will be incorporated into the G-D WQA model development as appropriate.
- The University of Washington (UW) is working jointly with King County on several projects supplementing the SWAMP project. The UW School of Fisheries is working on the ecosystem dynamics component and the bioaccumulation study for the model. The UW Department of Civil and Environmental Engineering is working on the lake-dynamics and biological processes modeling efforts and the mid-trophic model.

- UW is working jointly with King County on characterization of water quality conditions in the Mill Creek/Mullen Slough basin. Water quality data in Mill Creek/Mullen Slough were identified as a data gap in the model selection report (<ftp://dnr.metrokc.gov/hydrodat/GDWQA/>); data collected will be used to develop models for the G-DWQA.
- King County, WDFW, Seattle Public Utilities, and the Muckleshoot Tribe are conducting chinook surveys in the main stem of the Cedar River.
- King County in partnership with the City of Kirkland is conducting habitat surveys in the Juanita Creek area.
- The Salmon Watcher Program trains volunteers to observe, count, and identify salmon in streams. King County conducts this work in partnership with Seattle, Bellevue, Redmond, Federal Way, Snohomish County, WDFW, and the Muckleshoot Tribe.
- King County Department of Transportation, Roads Services, conducts water quality and macroinvertebrate sampling at several road crossing sites within the Green-Duwamish River watershed. The sites, parameters, and methods differ from those of the G-DWQA. The G-DWQA is designed to address some of the remaining data gaps.
- The Puget Sound Ambient Monitoring Program is coordinated by the Puget Sound Water Quality Action Team and is a long-term effort to investigate environmental trends and prevent overlaps and duplication in monitoring efforts. King County participates in this program, the only local entity to do so, to ensure that there are no overlaps with other monitoring efforts.
- The Washington State Department of Health collects marine water samples for bacterial analysis (fecal coliform) in King County at two locations on Vashon Island. They also analyze shellfish tissues for Paralytic Shellfish Poisoning (PSP) at these same locations as part of a larger statewide sampling program to protect consumers of shellfish. None of the bacteria stations overlaps with King County stations, and the County does not monitor PSP.
- The National Oceanographic and Atmospheric Agency (NOAA) samples three stations in King County for chemical contaminants in mussels as part of the national Mussel Watch Program. NOAA Fisheries has sampled salmonids in the Duwamish River for evidence of chemical impairment. The County uses this information in its studies.
- The Port of Seattle monitors sediment quality at Port-owned property in King County. There is no overlap with County stations.
- The U.S. Army Corps of Engineers is required to monitor sediment quality during routine maintenance dredging, which often occurs in the Duwamish River. The County uses this information in its projects.
- The City of Seattle monitors sediment quality at some of its CSOs and storm drains. The County uses this information in marine modeling efforts.

Chapter 4

Program Results—State of King County Waters

This chapter summarizes the state of the waters within the wastewater service area of western King County. Monitoring and management performance in 2003 indicates that County efforts continue to make a significant contribution to protecting regional water quality and public health. No needs were identified that are not being addressed, and the wastewater system is achieving its purposes. Continuing vigilance by agencies like King County is recommended though, as the pressures of urbanization on water quality are increasing. King County residents will then continue to enjoy the excellent water quality that they value and expect.

Cedar-Sammamish Watershed (WRIA 08)

Water quality in the major lakes of the Cedar-Sammamish watershed—Lake Sammamish, Lake Washington, and Lake Union – continues to be good in 2003. Water quality, as described by the Trophic State Index, has fluctuated between moderate (mesotrophic) and good (oligotrophic) over the last nine years. Lakes Sammamish and Washington were considered good 70 to 80 percent of the time and have consistently maintained good water quality for the last four years. Lake Union was more often of moderate quality (good 30 percent of the time). Figure 8 illustrates the variability in each lake from year to year (1994–2003). Often these year-to-year changes are the result of regional climatic differences (e.g., drought and cooler summer temperatures) and appear as similar fluctuations in the lines for all three lakes.

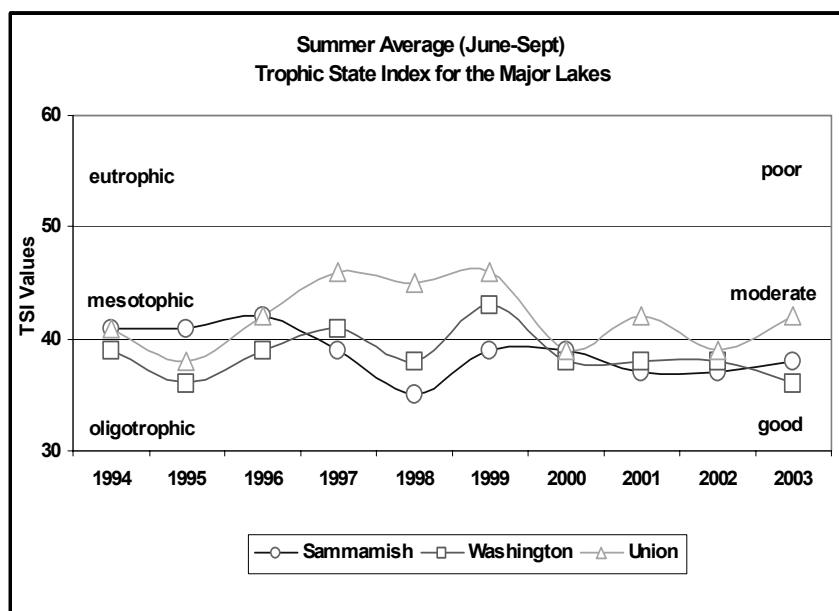


Figure 8
Average Summer Trophic State Index for Major Lakes
in the Cedar-Sammamish Watershed

Lake Washington

Water Quality

Lake Washington can be characterized as having good water quality (oligotrophic) in 2003, as shown in Figure 9. Water clarity was good (measured as Secchi transparency), phosphorus values were low, and algal levels (measured as chlorophyll-*a*) were moderate to low, except in late June and early July. The wastewater system goals of reduced nutrient loading and subsequent reduction in algal biomass have been achieved, and improved stormwater management practices have prevented increases in nutrient enrichment that often result from the type of extensive development that has been occurring in the area.

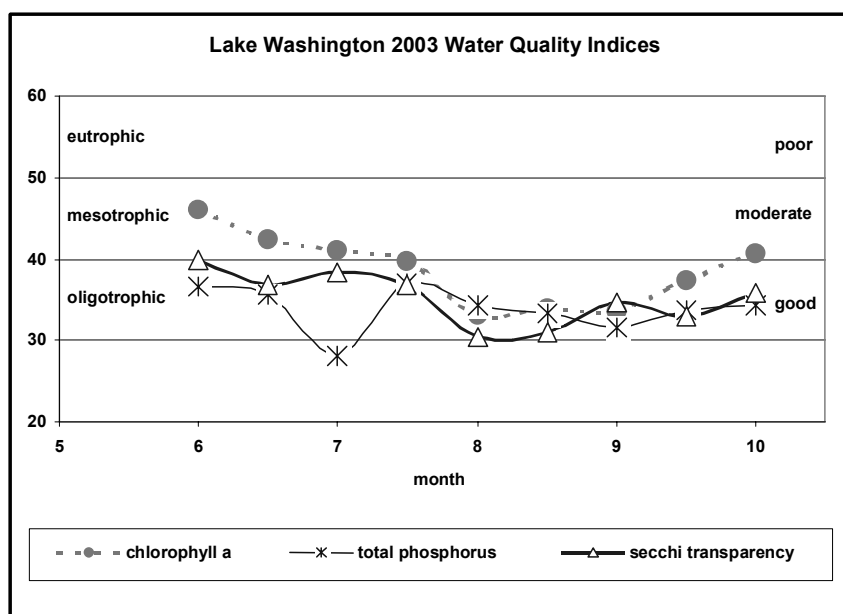


Figure 9
2003 Water Quality Indices for Lake Washington

Sediment Quality

Sediment samples were collected from 26 sites throughout Lake Washington and analyzed for chemistry, toxicity and benthic community structure. A preliminary analysis of these data was conducted using a modified Sediment Quality Triad (SQT) approach. The SQT was developed as a method for assessing sediment quality when sediment chemistry, toxicity and benthic data are all available at a site; all three data types are combined to evaluate the level of adverse impact under a weight-of-evidence approach.

A number of metals and organic compounds were detected above sediment quality guidelines (non-regulatory, professional judgment-based measures), toxicity was observed at 9 of the 26 sites and benthic data suggests that some sites do not support a healthy benthic community. Using the SQT approach, sampling locations were classified as having high, moderate, low and no impact. Nine of the 27 sites were considered to be highly or moderately impacted, while the remaining 17 sites were considered to have low or no impact.

A detailed SQT assessment is currently being completed for all three of the major lakes (Sammamish, Union and Washington). The results will provide an assessment of sediment quality and provide County scientists with the information necessary to identify areas of concern, and assist in identification of future sampling programs. This analysis and associated report is anticipated to be complete in late fall 2004.

Lake Sammamish

Water Quality

Overall water quality was good in Lake Sammamish in 2003, as shown in Figure 10. Table 6 shows that all the goals for phosphorous and clarity were met in 2003. The average summer chlorophyll-*a* was slightly higher than the goal. Algal volumes (measured as chlorophyll-*a*) were high in early spring (March and April) but declined by the summer months with another, smaller, peak in July. Generally, conditions in the basin are good and nutrient concentrations and subsequent algal biomass has been low in Lake Sammamish since 1997.

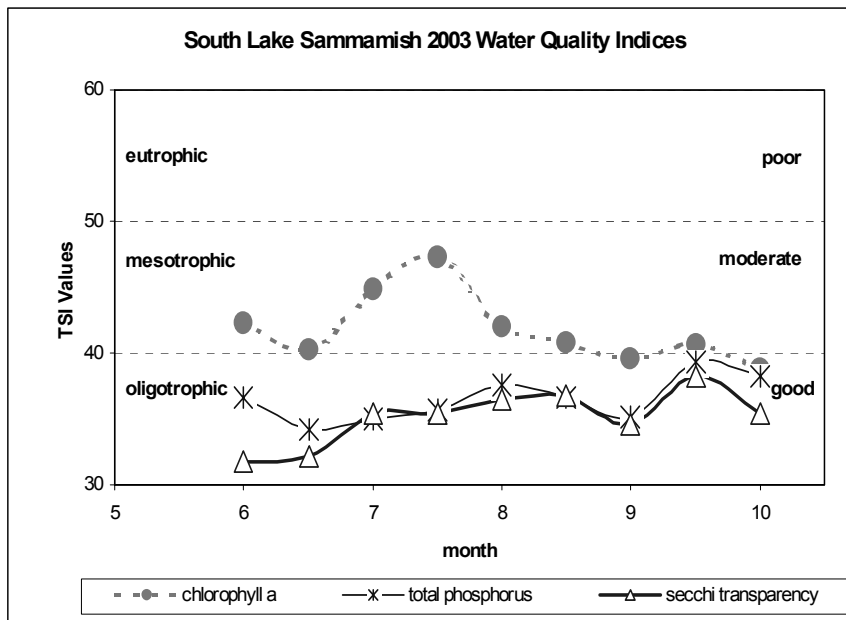


Figure 10
2003 Water Quality Indices for Lake Sammamish

Table 6
Water Quality Goals and Values for Lake Sammamish

	Mean Annual Volume Weighted Total Phosphorus (ug/L)	Summer Chlorophyll- <i>a</i> (mg/m ³)	Summer Secchi Depth (meters)
Goals*	22	≤ 2.8	≥ 4.0
2003 Values	12.0	3.3	5.7

*As defined in the *Lake Sammamish Management Plan* in 1989.

Sediment Quality

The highest levels of sediment-associated contaminants in Lake Sammamish were found in the vicinity of stormwater discharges and at deep lake locations. A number of metals and organic compounds were found to exceed the sediment guidelines throughout the lake; however, toxicity test results suggest that sediment-associated contaminants are creating adverse impacts in only a few areas.

Benthic data are currently being analyzed and will be compared to both the toxicity and chemistry data (e.g., sediment triad analysis). A challenge to this analysis will be to differentiate whether impacts to the structure of benthic communities occur from sediment-associated chemicals or from phosphorus loading.

Application of the SQT approach (see Lake Washington section above) is currently being completed for Lake Sammamish. This analysis and associated report is anticipated to be complete in late fall 2004.

Lake Union

Water Quality

Lake Union has historically been characterized as mesotrophic (moderate water quality) with fluctuations in some years to oligotrophic conditions (good water quality). Measurements taken over the summer of 2003 characterized Lake Union as having moderate water overall. Figure 11 shows that phosphorus and algal biomass declined in July and early August, only to increase again by September. Water clarity, as expected, increased when algal biomass was low and decreased when high.

Historically, thermal stratification has caused oxygen deprivation (anoxic conditions) in the lake bottom waters. The optimal oxygen concentration for salmonids is between 6 and 8 mg/L. Dissolved oxygen (DO) concentrations become critical for fish survival at 4.25 mg/L and lethal below 2.0 mg/L. Temperatures for salmonids are optimal between 12 and 16 °C, critical around 18 °C, and lethal at 23 °C. By June 16, water at depths greater than 10.5 meters had DO concentrations less than 5 mg/L while temperatures were at 18 °C or above in the top seven meters. By early September, DO concentrations at depths below 10.5 meters were less than 2 mg/L and temperatures were at 22 °C or greater in the top seven meters of the lake, substantially reducing available habitat for salmonids.

When DO concentrations drop below 2 mg/L at the sediment interface, phosphorus that is bound with iron in the sediment dissolves and is released into the water column. This process

was evident in Lake Union as the summer stratification progressed. Total phosphorus concentrations at 14 meters increased from 26 μ g/L on June 2nd to 945 μ g/L by September 2nd.

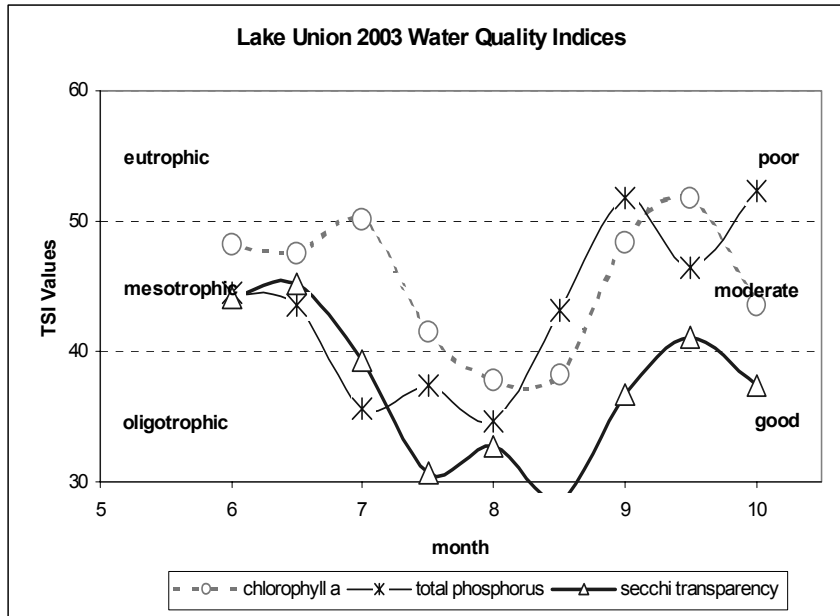


Figure 11
2003 Water Quality Indices for Lake Union

While the lake remains stratified, the increased phosphorus concentrations in the bottom waters do not mix vertically and therefore do not influence the phosphorus concentrations lake-wide until the water column mixes in late fall or early winter.

Sediment Quality

Sediment samples were collected from 16 sites throughout Lake Union and analyzed for chemistry, toxicity and benthic community structure. A number of metals and organic compounds were detected above sediment quality guidelines, toxicity was observed at some locations and benthic data suggests that some sites do not support a healthy benthic community.

Application of the SQT approach (see Lake Washington section above) is currently being completed for Lake Union. This analysis and associated report is anticipated to be complete in late fall 2004.

Small Lakes

Volunteers sampled 48 lakes over King County. Results for 2003 are not yet available, but as of 2002 many lakes are maintaining their quality, while several appear to making gains in water quality demonstrated by decreasing Trophic State Indexes. 2003 results will be posted on the website and reported in the annual report.

Rivers and Streams

Thirty-six sites on 2 rivers and 22 streams have been sampled monthly in the Cedar-Sammamish watershed (WRIA 08) under baseflow and wet weather conditions—some for over 20 years. The two main rivers in the watershed are the Sammamish River and the Cedar River.

Sammamish River

The Sammamish River is listed on the Washington Department of Ecology's (Ecology's) 1998 303(d) list for exceeding standards for temperature, DO, pH, and fecal coliform. High river temperatures typically result in low dissolved oxygen concentrations since warmer water holds less dissolved gases. Higher temperatures and subsequent lower dissolved oxygen concentrations occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature is considered one of the most serious water quality problems, limiting beneficial uses in the river. River temperatures as high as 80°F in late July have been observed, which is far above the lethal limit for salmon. High temperatures can affect reproductive health and survival of all adult fish entering the river. Elevated but sub-lethal temperatures common in June and July can also cause feeding alterations, decreased resistance to disease, and even mortality in juvenile salmon.

Tracking of adult chinook in 1998 and 1999 indicated that salmon use every deep area in the river during migration, likely in an attempt to find cooler water conditions. The most serious temperature problems are located where the warm surface waters of Lake Sammamish feed the river. The relationship between the lake and river suggests that the Sammamish River has historically been warmer than many Northwest rivers in the summer and early fall. However, the historical river channel conditions likely provided significantly more cool-water refuge for salmon than is currently available. The historical channel meandered through a vast wetland complex that dominated much of the corridor, providing greater shade cover, more pools, and greater connection with groundwater and tributaries, all of which contributed to maintaining cooler river temperatures.

To better understand the issue of increased temperature in the Sammamish River, the County has been evaluating the conditions that influence the overall temperature in the river (e.g., riparian vegetation conditions, groundwater, and influence of tributary flow) through SWAMP, which is described in Chapter 2. In addition, computer models are being developed to help identify which potential restoration options would have the greatest influence on decreasing temperature in the river; for example, increased shading, increased groundwater inflow, or provision of a cool-water inflow source.

Sediment Quality

To better characterize the presence of toxic chemicals, King County collected sediment samples in 2001 and 2003 and water samples for each year from 2001 to 2003 in the Sammamish River. Water and sediment samples were analyzed for various chemicals such as pesticides, metals, conventional parameters, and nutrients. In addition to chemical analyses, the County is evaluating sediment samples to determine the overall health of the populations of aquatic organisms living in the riverbed. Evaluating the types and numbers of organisms present in river sediments provides additional information on the overall ecological health of the river. Samples were collected from 10 locations throughout the 13-mile length of the river. Sampling sites were located below major tributaries and in the vicinity of potential pollution

sources. King County has analyzed the chemistry and sediment community samples and is currently comparing the results to sediment and water quality thresholds. The results of this assessment will be available by summer of 2004.

Cedar River

The Cedar River is listed on Ecology's 1998 303(d) list for fecal coliform bacteria. The lower main stem of the Cedar River and major tributaries provide the majority of the spawning habitat for chinook, sockeye, and steelhead, as well as significant spawning and rearing habitat for coho and cutthroat trout. The WRIA 08 Technical Committee identified the following mainstem factors of decline for chinook: access and passage barriers, loss of channel complexity and connectivity, degradation of riparian conditions, altered hydrology and flow, and increased and altered sedimentation. Details of the factors of decline and proposed action alternatives are collated in the *Lake Washington/Cedar/Sammamish Watershed (WRIA 08) Near Term Action Agenda for Salmon Habitat Conservation* (February 2002).

Small Streams

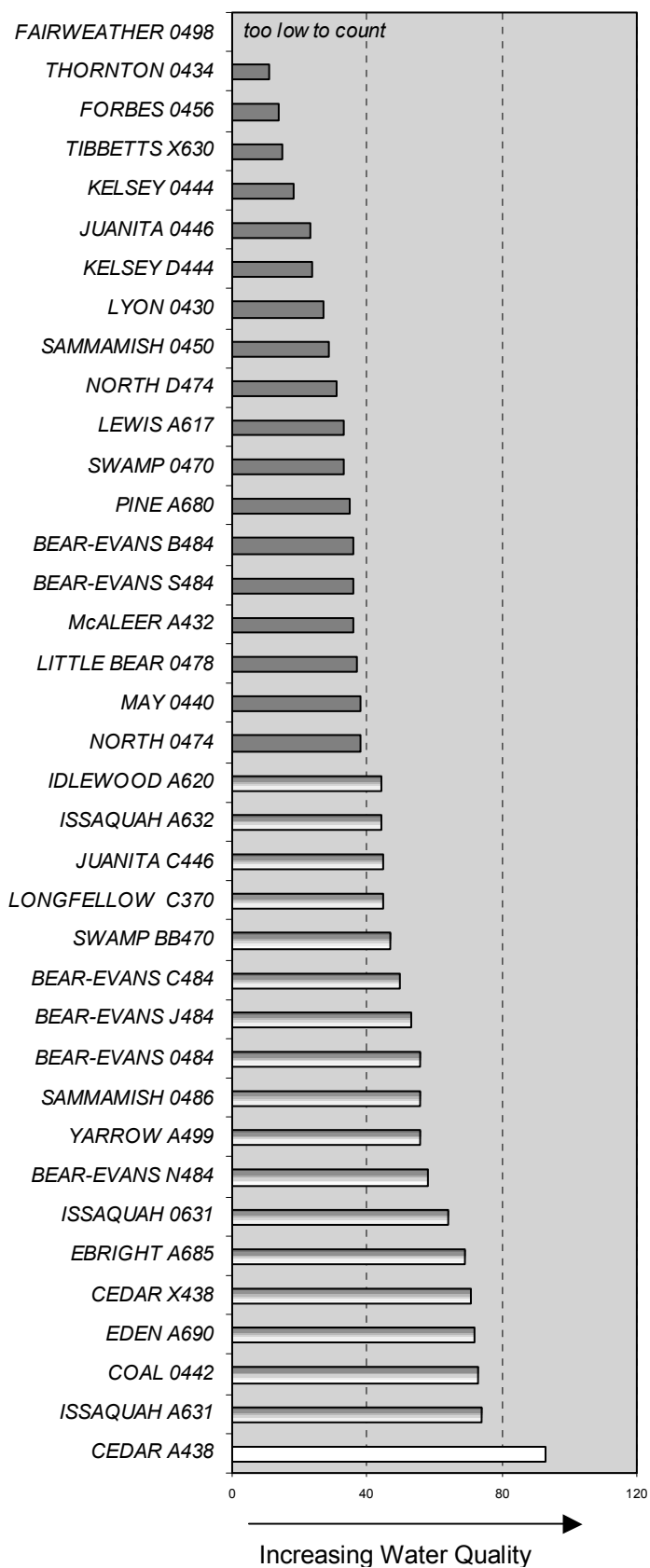
As part of the County ambient monitoring program, 37 sites on 23 streams and two rivers have been sampled monthly in WRIA 08 under baseflow and wet weather conditions.

For this report, the data from October 2002 through September 2003 were used to evaluate the water quality conditions using Ecology's Water Quality Index (WQI), modified slightly to better represent county rivers and streams. Water quality at only one site in WRIA 08, Cedar River, had a high enough water quality ranking to be considered a "low concern" site (Figure 12). Seventeen sites were ranked in the "Moderate Concern" range. The following nineteen sites on 16 streams and one river ranked of "high concern" in the WRIA 08 watershed: Fairweather, Thornton, Forbes, Tibbetts, Kelsey, Juanita, Lyon, North, Lewis, Swamp, Pine, Bear-Evans, McAleer, Little Bear, May, and the mouth of the Sammamish River.

Overall, "high concern" ratings were caused at least in part by excessive bacteria levels at 19 of the sites in WRIA 8. Low dissolved oxygen and/or high phosphorus concentrations were also a problem at some of the "high concern" sites. Seven of the sites with high bacteria counts are in urban areas (Springbrook-0317, North-0474, Fairweather-0498, Thornton-0434, Lyon-0430, Juanita-0446, Little Bear-0478 and McAleer-A432), three are downstream of agricultural activities (North-D474, May-0440 and Evans-B484), and four sites are downstream of wetlands (Forbes-0456, Kelsey West Branch-D444, Tibbetts-X630 and Pine Lake Creek-A680). Pets and failing septic systems are the most likely sources of bacteria in the urban areas. Poor livestock management practices can be a potential source of bacteria in agricultural areas. In wetland areas, wildlife and stagnant water conditions can lead to elevated bacteria counts. High phosphorus concentrations are found in fecal material and elevated concentrations are often linked to similar sources as bacteria. In addition, elevated phosphorus concentrations are linked to areas with high volumes of stormwater runoff and areas undergoing development.

Two sites were rated "high concern" solely due to low dissolved oxygen concentrations (Swamp-0470 and Upper Evans-S484). Low dissolved oxygen concentrations can be associated with low flows, high temperatures (warmer water holds less oxygen), and high levels of organic matter (bacteria use up oxygen in the process of decomposition). Low flows and high temperatures were a particular problem during the 2002-2003 water year as

Figure 12
WRIA 8
Rivers & Streams
Water Quality Index
Scores
Oct 2002 - Sept 2003



precipitation levels were well below the historical average. Check out the County Hydrologic web site at: <http://dnr.metrokc.gov/hydrodat/bbs.htm> for more information about rainfall patterns in the last few years.

Small Streams Pesticide/Toxicity Study

The biological implications of pesticides in small streams were assessed by collecting water quality samples seasonally during both baseflow and storm conditions. 12 urban and suburban creeks, and one reference creek located in an undeveloped basin, were sampled. All streams were located in WRIA 8 in King County. The samples were analyzed for over 150 different pesticides, 13 different metals (dissolved and total), and toxicity to three different test species. The three different test species represent different levels of the food chain in an aquatic community. Additionally, threshold effects levels were developed for all chemicals that were detected but do not have water quality standards. A threshold effects level is a concentration, which is derived from the scientific literature, below which adverse effects are not expected. Collecting chemical and toxicity information together gives researchers two separate data sets to analyze, which adds certainty to conclusions. Data from the first four years of this five-year study are summarized below.

Findings

One of the significant findings of the study is that pesticide and herbicides are consistently present in small urban and suburban streams during baseflow when storm water is not washing off the landscape and running into streams. While pesticide concentrations increased during storm events, these results show that the concentrations do not return to zero after the storm and that pesticide exposures in urban creeks are not short-term acute exposures during stormwater runoff, but are a chronic exposure. The aquatic community in these streams is almost continually exposed to pesticides.

Threshold effects levels and water quality standards were exceeded in 16 samples. Diazinon exceeded in 7 samples, copper in 3, simazine in 2, DDT in 2, lead in 1, and malathion 1. Toxicity was observed in 25 samples. It is reasonably clear that the chemicals exceeding the thresholds or standards also caused the observed toxicity.

Of the 25 samples in which toxicity was observed, 19 of them did not exceed a threshold effect level or water quality standard for any chemical that was tested. It is possible that the observed toxicity resulted from untested chemicals. While this study tested for over 150 different pesticides, over 600 are licensed for use in the State of Washington.

Classical toxicity tests, such as the ones used to develop threshold effects levels for this study, do not account for interactions between multiple chemicals. These chemicals may exert toxic influences independently, they may be additive, they may magnify other effects, or they may oppose other effects. We do not yet have the ability to measure such interactions.

This study has shown that pesticides are not only present during storm runoff events, but also during baseflow. This indicates that pesticide exposure to the aquatic community may be continuous, spanning many generations.

Brightwater - Initial Surface Water Characterization

Water quality measurements are being taken to characterize the quality of waters leaving the Route 9 site as well as to characterize Little Bear Creek upstream and downstream of the site. Auto-samplers are located at each of the monitoring stations and will be activated such that collections will begin near the same time depending on surface water runoff response. Water quality parameters to be analyzed for this project are conventionals (Alkalinity, biochemical oxygen demand (BOD), total dissolved solids, total suspended solids, and turbidity) and in-stream parameters (temperature, pH, dissolved oxygen, and specific conductance.)

Sampling began in October 2003 in an attempt to capture low flow conditions prior to the start of our normal wet season (typically October through May). Sampling will continue through part of the next wet season ending in December 2004, and may be expanded in scope and extended. Results will be available in 2005.

Duwamish-Green Watershed (WRIA 09)

An assessment of the current water quality conditions in the Green-Duwamish watershed was compiled in 2000 from water quality reports and from analysis of water quality data collected between 1996 and 1999. Numerous streams in the watershed are listed on Ecology's 1998 303(d) list of water bodies that do not meet Water Quality Standards. These include portions of the Duwamish River, lower Green River, Springbrook Creek, Mill Creek, Mullen Slough, Soos Creek, and Newaukum Creek. Fecal coliform bacteria, DO, and temperature are the most common parameters listed, but there are also isolated listings for pH, metals, and ammonia.

Fecal coliform bacteria typically exceed standards during storm conditions in all of these listed water bodies. DO and temperature typically exceed standards during warmer summer conditions when stream flows are lower. DO and temperature are mostly a problem in the tributaries, but are occasionally a concern in the Green River mainstem.

Small Lakes

Volunteers sampled 48 lakes over King County. Results for 2003 are not yet available, but as of 2002 many lakes are maintaining their quality, while several appear to making gains in water quality demonstrated by decreasing Trophic State Indexes. 2003 results will be posted on the website and reported in the annual report.

Green and Duwamish Rivers

In general, the water quality is good in the Duwamish Estuary. The risks to organisms that dwell in the water column are minimal; however, there are potential risks to benthic (sediment-dwelling) organisms from several chemicals in the sediments. Risks to the benthic organisms can potentially translate into risks to salmonids via food-chain transfer, reduction in immune system functioning, or reduction in available food. This is an example of why sediment remediation in the Duwamish River is of high priority for the County.

Small Streams

As part of the County ambient monitoring program, 17 sites on 5 streams and two rivers have been sampled monthly in WRIA 09 under baseflow and wet weather conditions. For this report, the data from October 2002 through September 2003 were used to evaluate the water quality conditions using Ecology's Water Quality Index (WQI), modified slightly to better represent county rivers and streams. Water quality at five sites in WRIA 09, Green River and Soos Creek, had a high enough water quality ranking to be considered "low concern" sites (Figure 13). Ten sites were ranked in the "Moderate Concern" range. Two sites, Mill Creek and Springbrook Creek, ranked of "high concern" in the WRIA 09 watershed.

Overall, "high concern" ratings were caused in part by excessive bacteria levels at 4 sites in WRIA 9. Low dissolved oxygen concentrations and/or high phosphorus concentrations were also a problem at Springbrook Creek. Springbrook Creek flows through an urban area. Pets and failing septic systems are the most likely sources of bacteria in the urban areas.

Mill Creek is downstream of agricultural activities where poor livestock management practices can be a potential source of bacteria. In wetland areas, wildlife and stagnant water conditions can lead to elevated bacteria counts. High phosphorus concentrations are found in fecal material and elevated concentrations are often linked to similar sources as bacteria. In addition, elevated phosphorus concentrations are linked to areas with high volumes of stormwater runoff and areas undergoing development.

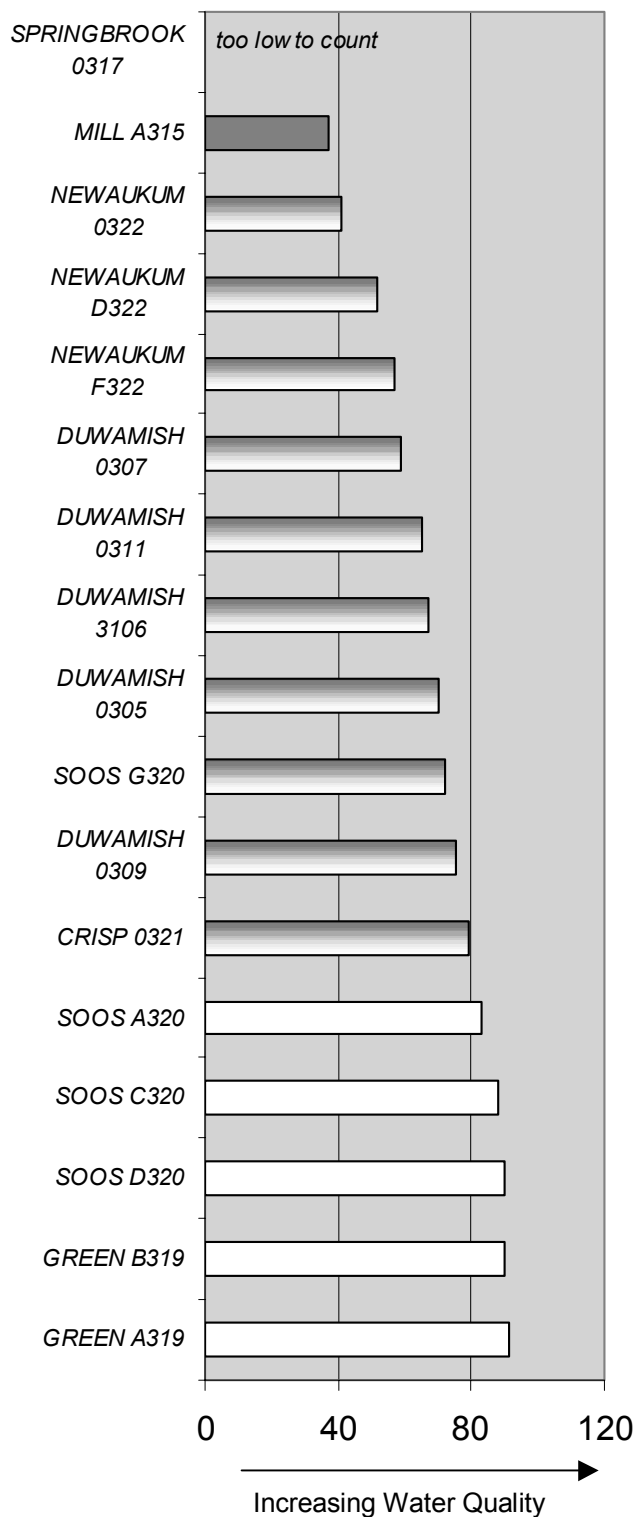
Historical Water Quality Trends and Salmon

The G-D WQA has completed an analysis of all historic water quality data available for the Green and Duwamish. Water quality conditions in the Lower Green and Duwamish River have improved from the poor water quality conditions that existed in the 1960s and earlier. This is a result of the reduction of municipal and industrial discharges including the relocation of the South Treatment Plant's from the Lower Green to Puget Sound.

There has been a trend towards increasing surface water temperatures in most tributaries in the urban and urbanizing areas of the region over the past 20 years, probably attributable to factors such as increased runoff from impervious surfaces and loss of riparian vegetation that can result from development and urbanization.

In studies conducted using continuous monitoring probes along the main stem of the Lower and Middle Green River, temperatures were seen to peak between 23 and 24 °C during the summer. In some years, this is probably of concern for adult chinook migrating in August and early September. Water temperatures in some tributaries of the Mill and Springbrook sub-basins have been historically high and are probably of concern for salmonid rearing. Water temperatures during spawning and rearing are also of concern for several Soos Creek tributaries. Analysis of the recently collected baseflow and stormwater sampling data will allow more complete exploration of changes in temperature and its effect on fisheries and other aquatic resources.

Figure 13
WRIA 9
Rivers and Streams
Water Quality Index
Scores
Oct 2002 - Sept 2003



Dissolved oxygen (DO) levels are one of the most significant issues for salmonids in the basin. DO levels in the mainstem of the Duwamish and Lower Green rivers are of concern for salmonid rearing on some occasions. DO levels in the mainstem of the Middle Green River (above RM 24) - where most mainstem spawning occurs - are occasionally of concern during incubation. DO for incubation and rearing is a probable factor of decline for salmonids in several tributaries, particularly Springbrook Creek, Mill Creek, Soos Creek and Newaukum Creek. The most severe documented DO problem is in the Mill Creek basin.

Turbidity and total suspended solids (TSS) are possible factors of decline in terms of water column impacts for the Duwamish River, Lower Green River, Mill Creek and Springbrook Creek. Analysis of recent data will shed more light on this issue.

Recent data from King County streams indicate that pH, ammonia, and metals are unlikely to be factors of decline for salmonids. Exceptions include the Mill Creek basin where ammonia may be a factor of decline, and Springbrook Creek where metals (cadmium, chromium, copper, mercury, and zinc) may be of concern. It is possible that there are localized areas near stormwater outfalls where metals could also be of concern. This historic information, along with the recent baseflow and stormwater sampling completed in 2003, will be used for modeling of the watershed to predict future conditions and explore ways of reducing water quality impairments.

Microbial Source-Tracking Study (G-D WQA)

The present microbial source tracking study will collect information on bacterial sources and land uses associated with bacterial populations. Sampling began in January 2003 and will complete in early 2004. A final report on the findings will be issued in mid-2005.

Puget Sound Marine Waters

Only locations sampled in Puget Sound since the adoption of the RWSP in 1999 are discussed because stations change with changing program goals over time. Sampling locations prior to 1999 may be found in the appropriate yearly *Water Quality Status Report for Marine Waters* produced by King County's Department of Natural Resources & Parks, Water and Land Resources Division.

Water Quality at Ambient and Outfall Locations

Dissolved Oxygen

Dissolved oxygen (DO) concentrations in Puget Sound between late winter and early summer are generally above 7.0 milligrams per liter (mg/L) at all depths and locations sampled and are usually above 5.0 mg/L, the level at which potential problems could occur. Concentrations below 7.0 mg/L naturally occur in the late summer and fall as a result of a seasonal influx of deep oceanic water, which contains low amounts of DO. Figure 14 shows the seasonal variation in DO concentrations for 2003 and concentrations at both ambient and outfall sites.

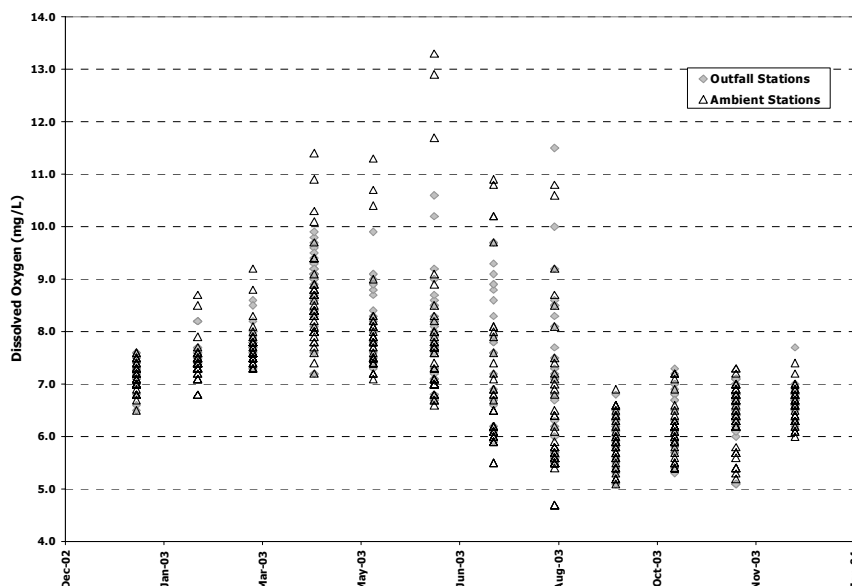


Figure 14. 2003 Puget Sound Dissolved Oxygen Concentrations

There was no apparent difference in DO concentrations between outfall and ambient monitoring stations. There was only one occurrence of a DO concentration below 5.0 mg/L (value was 4.7 mg/L) in 2003, which was measured in August at an ambient station in central Elliott Bay.

Fecal Coliform Bacteria

Routine fecal coliform testing measures the amount of bacteria present but does not distinguish whether the bacteria are from a human or animal source. Source tracing requires specialized sampling and analysis techniques that must be performed at the University of Washington or another specialized laboratory. With the exception of one station located in central Elliott Bay, all offshore water column stations met both fecal coliform criteria throughout 2003. The central Elliott Bay station met the geometric mean criterion but failed the peak criterion for the first four months of 2003. All fecal coliform counts at the wastewater treatment plant and CSO marine outfalls were well below both water quality criteria. Figures 15 and 16 show the distribution of fecal coliform bacteria counts in offshore water column samples. Figure 15 illustrates that fecal coliform bacteria were not seen in the majority of samples collected (279 out of 357 samples). Figure 16 illustrates the distribution of fecal coliform bacteria counts between ambient and outfall monitoring stations, including the Denny Way CSO outfall in Elliott Bay. The highest fecal coliform results were measured at the Denny Way CSO outfall where there is a strong freshwater influence on bacteria concentrations.

Figure 15
2003 Fecal Coliform Bacteria in Puget Sound Waters

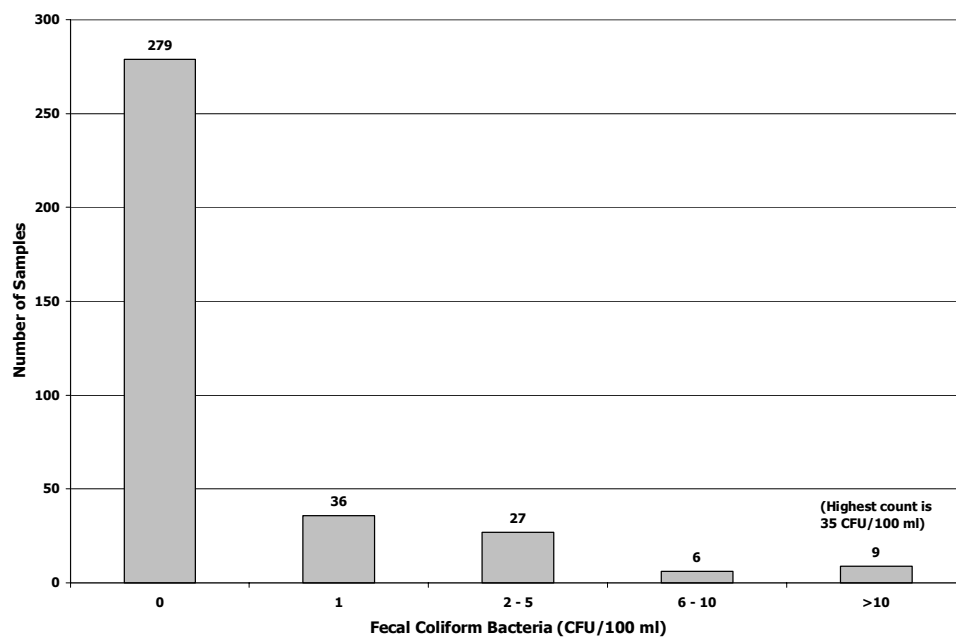
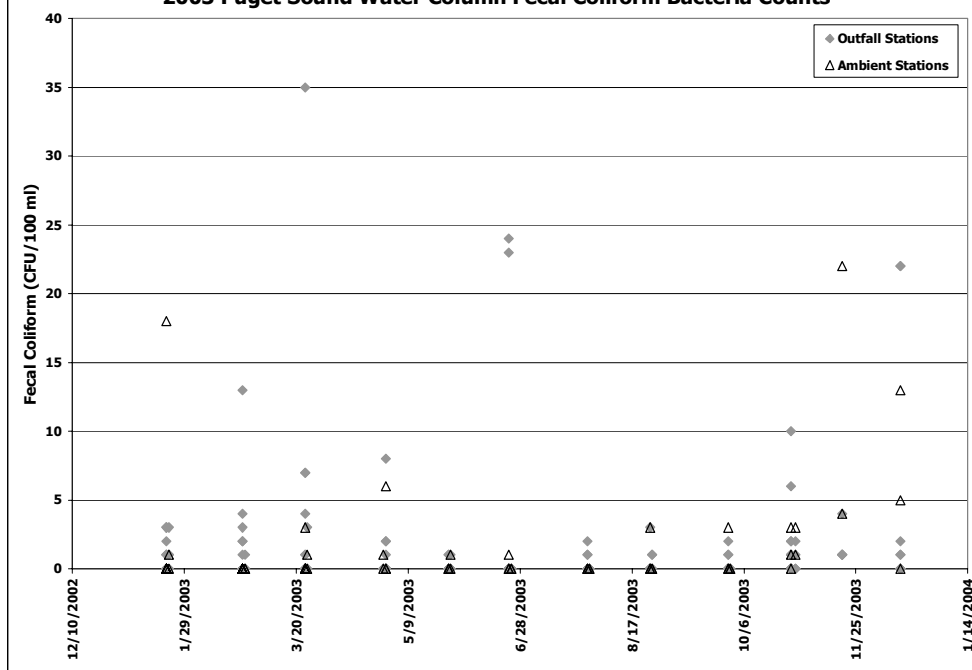
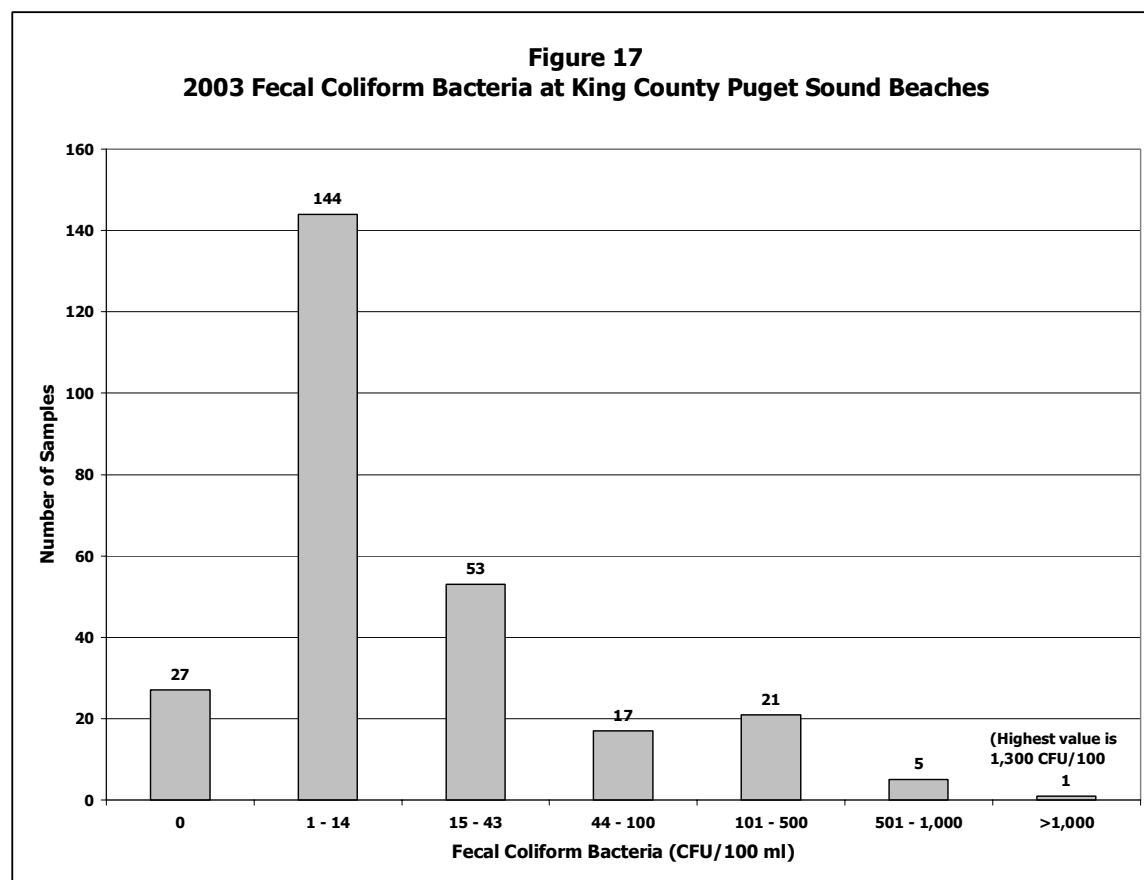


Figure 16
2003 Puget Sound Water Column Fecal Coliform Bacteria Counts



Fecal coliform levels in water samples collected from beaches are influenced by freshwater and stormwater runoff and by waterfowl that congregate in these areas. As a result, a number of stations close to streams and other freshwater sources routinely exceed water quality criteria during high rainfall months. Stations that are in areas with restricted water movement also tend to exceed criteria more frequently than do areas with ample mixing. Beach sampling stations that routinely exceeded both fecal coliform bacteria water quality criteria in 2003 included Shilshole Bay, Alki Point (south of the Alki Treatment Plant), Fauntleroy Cove, Pier 48 in Elliott Bay, and Tramp Harbor on Vashon Island. Beach stations that met both criteria throughout 2003 include Richmond Beach, Seacrest Park, Duwamish Head (the northern tip of West Seattle), Alki Beach, and Lincoln Park. Figure 17 shows a distribution of fecal coliform bacteria counts at King County marine beaches.

Fecal coliform bacteria levels at beaches in the vicinity of the West Point Treatment Plant outfall met the geometric mean criterion in 2003 but generally did not meet the peak level criterion. Bacteria counts at Piper's Creek in Carkeek Park routinely failed both water quality criteria in the past, but met both standards during the last five months of 2003. Bacteria counts at a beach in the vicinity of the Alki CSO treatment plant outfall, which rarely discharges, have consistently failed both criteria. The reason for these failures is not clear. Further investigation is required to determine the bacteria source.



Nutrients

Nutrients, including nitrogen (in the form of ammonia, nitrate, and nitrite), phosphorus, and silica are ubiquitous in the marine environment in varying concentrations. Nitrate is the primary form of inorganic nitrogen in seawater. Nitrate concentrations are usually higher in the winter months when phytoplankton growth is the lowest and freshwater flows are the highest. Nitrate values are typically lower in the upper parts of the water column where marine plants take up nitrate for photosynthesis. Nitrate concentrations at beach stations were similar to offshore stations with the same seasonal trends. Nitrate concentrations at outfall stations were similar to values measured at ambient stations.

All ammonia concentrations measured for offshore and beach stations over the last several years were well below the 1.6 mg/L chronic water quality criterion. In the past several years, the highest ammonia concentrations have been measured at the West Point and South Treatment Plant outfall stations, generally at the predicted effluent plume trapping depth and deepest depth for each site. Though higher, these ammonia concentrations were well below the criterion. Figure 18 shows ammonia profiles in 2003 for two ambient stations and the two main wastewater treatment plant outfall stations.

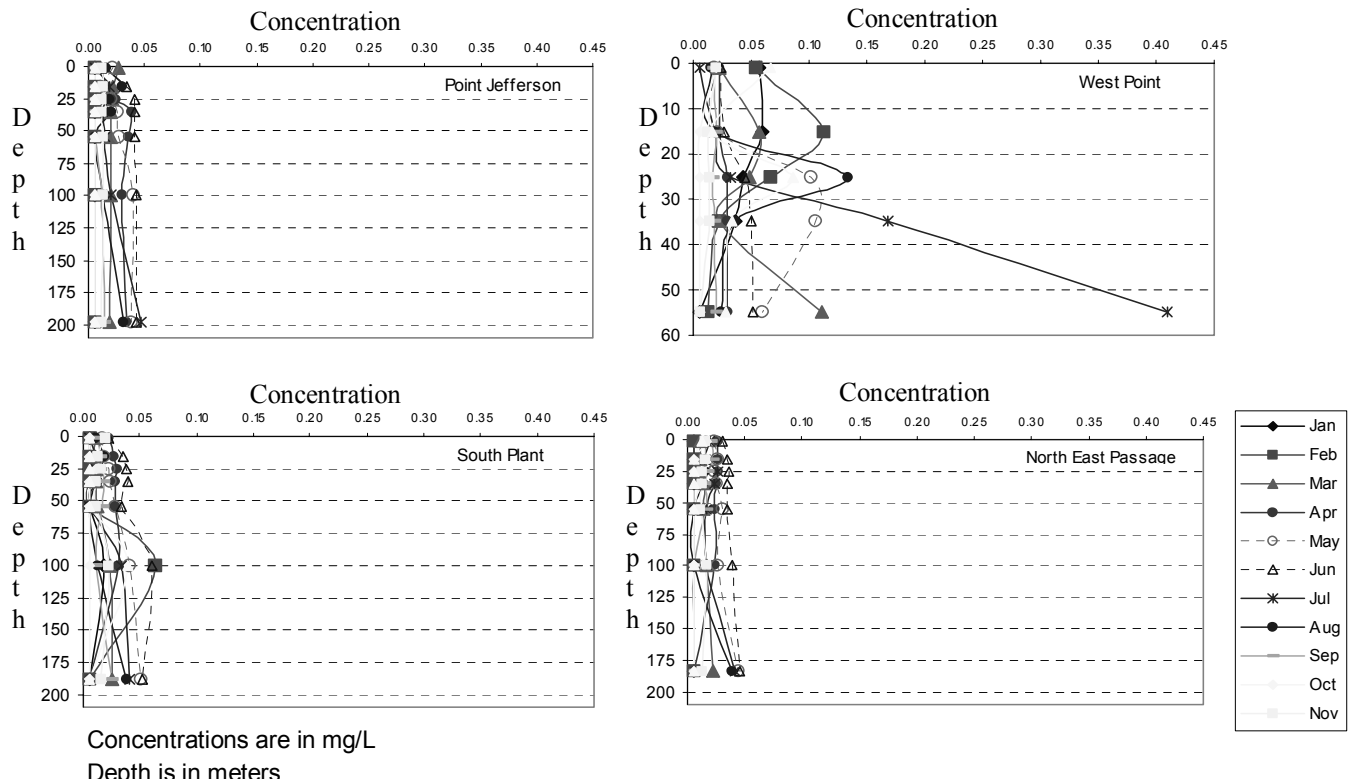


Figure 18
2003 Ammonia Profiles for Ambient and Outfall Sites in Puget Sound

Phytoplankton Blooms

Phytoplankton blooms (as indicated by chlorophyll-*a* levels in water samples) in the Central Basin of Puget Sound exhibit seasonal trends, with major blooms generally occurring between April and July of each year. In recent years, blooms have followed this same trend.

Chlorophyll-*a* data collected in 2003 indicated that an early phytoplankton bloom occurred in February, which was limited to the northern part of the Puget Sound Central Basin. Figure 19 shows the distribution of blooms throughout the Puget Sound Central Basin in 2003. The figure shows the months and sites where phytoplankton blooms occurred. The major blooms in 2003 followed typical patterns for Puget Sound, moving from north to south, and occurring between April and August this year.

Figure 19
2003 Phytoplankton Bloom Occurrence in Puget Sound
as Indicated by Chlorophyll-*a* Concentrations

Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Point Wells		>10 ⁵		>5 ⁶	>10	>10	>10	>5				
Jefferson Head		>10		>10	>10	>10	>10	>10				
Carkeek CSO Outfall				>5	>5	>10	>10	>5				
West Point Outfall				>10	>5	>5	>5	>10				
Denny CSO Outfall					>10		>5	>10				
Elliott Bay						>5	>10	>10				
Renton Outfall				>10		>10	>5	>10				
Alki Outfall				>5	>5	>10	>10					
East Passage					>10							
East Passage – North						>5	>10	>5				
Vashon Outfall							>5	>10				
East Passage – South				>10			>5	>5	>5			
VO50E						>10						
NSEX01						>10						

⁵ Stations with chlorophyll concentrations above 10.0 ug/L

⁶ Stations with chlorophyll concentrations above 5.0 ug/L

Sediment Quality

Treatment Plant Outfalls

Sediment monitoring at King County wastewater treatment plant outfalls has been completed until the next NPDES permit cycle. Sediments were not collected from any of the outfall monitoring sites in 2003.

Ambient Locations

Ambient sediments are sampled on a biennial basis in even-numbered years so no sediments were collected from ambient sites in 2003.

Brightwater Marine Outfall Subsurface Sediment Characterization

Subsurface sediments were collected from five borings along the nearshore alignment of the Brightwater marine outfall to determine the suitability of trenching spoils for disposal at a Puget Sound Dredged Disposal Analysis (PSDDA) program open-water disposal site. Preliminary analytical results indicate that the sediments are of sufficient quality to meet all PSDDA disposal requirements.

Denny Way CSO

Sediment samples were collected for chemical analysis in late 2003 in the vicinity of the previous Denny Way CSO outfall as well the two new outfalls. These sediments were collected as part of a long-term monitoring program for the Denny Way CSO improvement, required under provisions of the Biological Opinion issued for the project under the Endangered Species Act. The 2003 monitoring was performed to evaluate post-construction changes to sediment quality as well as to establish a pre-operation baseline around the new outfalls. Analytical results were not available at the time of this report and will be reported in a subsequent update.

Norfolk CSO

Remediation of the Norfolk CSO site was completed in 1999. Sediment samples collected in April 2003 represented the fourth year of the post-remediation monitoring program. Results indicated that sediment quality at the four monitoring stations in the remediation area had improved between 2002 and 2003. Concentrations of all detected chemicals were below Sediment Quality Standards chemical criteria.

Diagonal/Duwamish Remediation Dredging

To support the dredging process several monitoring efforts are underway and planned. Characterization of the sediments has been done to satisfy requirements for safe disposal. Sampling is being conducted to address site conditions in the Duwamish River before, during and after the dredging. The purpose of this sampling is to monitor for any spread of the contaminated sediments and compliance with water quality standards during dredging, and to document final improvement over original conditions. Water column samples taken during dredging showed that the chemicals of concern were found in low concentrations, and were below any existing water quality standards (mercury and PCBs).

The capping will be complete in early 2004. A 10-year post-remediation monitoring program will then begin to document cap stability and any chemical recontamination of the surface.

Chapter 5

Developing Issues and Needs

In the coming year, King County will face some unique challenges and some new opportunities for change. Creating a balance in water needs and water resources for fish and people continues to be an ongoing focus.

Endangered Species Act

Since 2000, King County has been engaged in three efforts related to the Endangered Species Act (ESA): preparation of a proposal concerning compliance with the ESA 4(d) rule, review of its practices for compliance with the chinook 4(d) rule, and preparation of a WTD Habitat Conservation Plan (HCP).

In 2000, NOAA Fisheries (formerly National Marine Fisheries Service, or NMFS) adopted a draft protective rule under section 4(d) of ESA prohibiting the “take” of salmon and steelhead species previously listed as threatened under ESA. In July 2001, the County submitted to NOAA Fisheries a proposal to include its wastewater discharges that are within NPDES permit limits and its discharges from controlled CSOs as a “limitation” on take, to be included for chinook salmon under the ESA 4(d) rule. A limitation means that if activities are conducted according to their description in the 4(d) rule, they are not considered to “take” or seriously harm the species population.

Following the adoption of the rule, King County began a review of its activities to determine how the Wastewater Treatment Division (WTD) should modify its practices to stay within the parameters set out in the 4(d) rule. Affected areas of our business include construction practices and uses of property near water bodies.

For treatment plant discharges, NOAA stated in the 4(d) rule that it would work with permitting authorities (Washington State Department of Ecology) to ensure that permitted discharges do not violate the ESA. The County is, therefore, concentrating its efforts on working with NOAA Fisheries and the U.S. Fish and Wildlife Service to develop a Habitat Conservation Plan to gain certainty regarding what we must do to develop projects that comply with the ESA. In 2003, the County participated in three public meetings hosted by the federal Services as part of the National Environmental Policy Act (NEPA) requirements for federal actions. In addition, regular negotiation sessions were held with the Services and the Tribes and an internal draft HCP was compiled for review in late 2003. It is anticipated that a draft HCP and NEPA EIS will be completed in 2004.

Watershed Resource Inventory Area (WRIA) Planning

Watershed planning activities under precedent-setting interlocal agreements (ILAs) continued in 2003—the third year of these activities. ILAs involve cost sharing by more than 45 jurisdictions in support of the salmon conservation planning effort as well as a new management construct. As a result of the success and accomplishments of the first three years, all jurisdictions have agreed to continue funding for 2004 work.

In both WRIAs 8 and 9, Near-Term Action Agendas (NTAAs) based on the scientific information gathered in the Reconnaissance Assessments provide voluntary opportunities for the short term. In 2003, the planning effort turned to development of Salmon Conservation Plans (also termed Habitat Plans). These plans will describe long-term habitat conservation and recovery actions in the WRIA 8 and 9 watersheds, taking an ecological approach but concentrating on the needs of the ESA-listed species of chinook salmon and bull trout. Development of elements of the plans will continue into 2004. Areas of initial work include modeling of the watershed and its responses to management changes, analysis of historical conditions, and analysis of land use.

Of equal importance, work on the Strategic Assessments continued in 2003 and will be completed in 2004. The Strategic Assessments will provide the technical foundation for the conservation plans as well as baseline information needed for adaptive management. The Strategic Assessments will result in a more complete understanding of problems and opportunities in the watershed related to salmon and salmon habitat conservation and recovery, with a focus on ESA-listed species.

Many of the questions that need to be answered in regard to the WRIAs are identical to those that the County's WTD must address in various projects. While the scientific needs of the WRIAs have been greater (for instance, in terms of geographic extent) than the specific needs of WTD, supporting the success of WRIA planning will ensure a sound framework for reasonable RWSP ESA requirements from the federal government.

Anti-Degradation Regulations

In July 2003, the Washington State Department of Ecology (Ecology) adopted revisions to its surface Water Quality Standards and procedures. Ecology modified its permit renewal processes to include stricter evaluations of projects that may lower or degrade water quality in state water bodies. This new anti-degradation procedure could potentially inhibit the siting of new discharges into water bodies with especially high water quality or those already impaired by a parameter (for example, temperature or dissolved oxygen) if it contributes to the reduction of a beneficial use (swimming, fish spawning, and so forth). These new requirements are under review by USEPA and upon approval by EPA, King County's future wastewater projects will be subject to these new procedures.

Total Maximum Daily Loads

Defined by the U.S. Environmental Protection Agency (EPA), a total maximum daily load (TMDL) is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet Water Quality Standards. When a waterbody fails to meet Water Quality Standards, the Clean Water Act requires that a TMDL and a pollutant allocation be done for that water body. The EPA or Ecology makes allocations of that pollutant to its sources, such as storm runoff or industrial discharges.

Any water bodies consistently identified by the state as not meeting Water Quality Standards must have a TMDL prepared. New federal rules for performing TMDL analysis were scheduled to go into effect in October 2001, but have since been rescinded. EPA was expected to propose new rules in 2003, but this did not occur. Under the current federal rules, many King County water bodies already listed by the State as having impaired water quality must have TMDLs prepared as soon as possible. As a result, King County will need to give increased attention to water quality data collection and modeling so that TMDL calculations done by Ecology will be based on good science and will be as accurate and complete as possible. On January 15, 2004 Ecology released its proposed updated list of impaired waterbodies as a part of a more comprehensive reporting on all the states waters. This new reporting will also list waterbodies where Ecology has concern that waters may be impaired but lacks the data to confirm this possibility, and those waterbodies that have no water quality data. This new reporting system may increase pressure on the state and local governments to undertake sampling programs that will more accurately assess local waters. The information required to site, construct or expand facilities will also likely increase.

In 2001, King County completed a joint project with the Ecology to begin work on TMDLs for certain county water bodies. In particular, a model sediment TMDL was developed and approved by EPA in its first application to a site in Bellingham Bay. This model should eventually be applied to the Lower Duwamish Waterway and other County remediation sites.

Endocrine Disrupting Chemicals

Chemicals that mimic hormones in animals (fish, birds, people) may sometimes result in changes in how an animal's endocrine or reproductive systems works. These chemicals have been called suspected endocrine disrupting chemicals (EDCs) or endocrine disrupters. Some of these chemicals may be found in treated municipal wastewater. King County has assembled a document to provide a review of the scientific literature on suspected endocrine disrupting substances that may be present in treated municipal wastewater. This document, entitled *Endocrine Disrupters in Secondary Treated Effluent: Toxicological Effects in Aquatic Species*, discusses EDCs, their effects on aquatic species, and the current state of research.

To add to the understanding of this issue King County also undertook some initial screening level sampling of its surface waters during 2003 to determine if there are measurable suspected EDCs present. A report on the results of this sampling is expected in 2004. The County was also one of 50 participants in an EPA study of effluents throughout the US.

The County will continue to follow this issue.

Sediment Contaminant Source Control

Source control of upland properties is needed to ensure that sediment cleanup sites are not recontaminated. In the Lower Duwamish Waterway and Harbor Island/East Waterway Superfund sites, the size of the industrial area makes source control particularly challenging. Effective of source control is very important to the County's CSO control program. If it is not successful, imposed solutions may include acceleration of project schedules or higher levels of control than is currently planned—either could have significant consequences for the RWSP capital program. To increase source control effectiveness a new intensive and integrated cross-agency source control effort is being implemented in the Diagonal/Duwamish basin. Coordination of programs from four separate programs to help businesses identify and control pollutant sources will now occur at one time through one contact with each business. In the next few years, the County will determine if this approach has been successful. For more information on this program, see the “Industrial Waste Program” section in Chapter 2 of this report.

Appendix A—Glossary

Algae: Plants that grow in surface waters in relative proportion to the amount of light, nutrients, and attachment sites available. Algae are food for fish and other aquatic organisms.

Benthos: The communities of aquatic life that dwell in or on the bottom of sediments of a water body.

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen required to meet the metabolic needs of microorganisms in water, wastewater and effluents.

Biosolids: The organic solids separated from raw wastewater or produced by the wastewater treatment process. Biosolids contain large amounts of organic matter.

Chlorophyll: The green pigment in plants that allows them to create energy from light (photosynthesis). By measuring chlorophyll, one indirectly measures the amount of photosynthesizing plants, or algae, in the water column. Chlorophyll- α is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Combined Sewer Overflow (CSO): An overflow of combined wastewater and stormwater. CSOs occur when stormwater from heavy rains exceed the capacity of the wastewater collection system.

Dissolved Oxygen (DO): The oxygen that is freely available in water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants and by aeration. Oxygen is consumed by animals, plants, and bacteria that decompose dead organic matter and some chemicals.

Effluent: Treated or untreated water or wastewater flowing out of a treatment facility, sewer, or industrial outfall. Generally refers to discharges into surface waters.

Eutrophic: The trophic state of lakes with high concentrations of nutrients and algae and with low transparency or clarity.

Eutrophication: The natural physical, chemical, and biological changes that take place as nutrients, organic matter, and sediment are added to a lake. When accelerated by human-caused influences, this process is called cultural eutrophication.

Fecal Coliforms: The intestinal bacteria from warm-blooded animals that are routinely used as an indicator of wastewater pollution in water and as an indicator of the human health risk.

Influent: Water, wastewater, or other liquid flowing into a treatment facility.

Mesotrophic: The trophic state of lakes that have moderate concentrations of nutrients and algae between those found in eutrophic and oligotrophic lakes.

National Pollutant Discharge Elimination System (NPDES): NPDES comes from Section 402 of the Clean Water Act. It prohibits the discharge of pollutants into navigable waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or a tribal government.

Nonpoint Source: An input of pollutants into a water body from unidentifiable sources, such as agriculture, the atmosphere, and stormwater or groundwater runoff.

Nutrient: An inorganic or organic compound essential for growth of organisms.

Oligotrophic: The trophic state of lakes with low concentrations of nutrients and algae and high transparency.

Phosphorus: The primary nutrient of concern in freshwater systems as it can cause nuisance algal blooms if present in excess amounts.

Phytoplankton: Marine plants, mostly small to microscopic in size, that are suspended in the water column and drift with the currents.

Point Source: An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Productivity: The rate at which organic matter is formed that is averaged over a defined period of time.

mg/L: Milligrams per liter. Used in describing the amount of a substance in a given volume of liquid. Equal to parts per million (ppm).

Secchi Depth: The measure of lake water clarity used primarily as an indicator of algal abundance. Clarity is affected by algae, soil particles, and other materials suspended in the water.

Thermal Stratification: Layering of lake water caused by differences in water density. During summer months, deep lakes divide into three layers: the epilimnion (uppermost, warmest layer), hypolimnion (lower, cooler layer) and metalimnion (middle layer).

Trophic State Index (TSI): One of the most common lake indices used to characterize water quality. Developed by Robert Carlson in 1977. This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, etc.) represents a doubling of algal biomass and is related to nutrient levels and transparency.

Water Column: The area of water contained between the surface and the bottom of a water body.

Appendix B—Web sites

Water Monitoring Programs

King County Environmental Laboratory

<http://dnr.metrokc.gov/wlr/envlab/index.htm>

King County Lakes Monitoring Program

<http://dnr.metrokc.gov/wlr/waterres/lakes/>

King County Beach Monitoring Program

<http://dnr.metrokc.gov/wlr/waterres/lakes/bacteria.htm>

King County Streams Monitoring Program

<http://dnr.metrokc.gov/wlr/waterres/streams/creekindex.htm>

<http://dnr.metrokc.gov/wlr/waterres/Bugs/index.htm>

King County Marine Monitoring Program

<http://dnr.metrokc.gov/wlr/waterres/marine/marine.htm>

Water Quality Management Programs

Wastewater Treatment Division

<http://dnr.metrokc.gov/wtd/>

King County's CSO Control Program

<http://dnr.metrokc.gov/wtd/cso/index.htm>

<http://dnr.metrokc.gov/wlr/waterres/wqa/wqpage.htm>

<http://dnr.metrokc.gov/wtd/dennyway/>

<http://dnr.metrokc.gov/wtd/henderson-cso/>

City of Seattle's CSO Control Program

<http://www.ci.seattle.wa.us/util/CSOPlan/default.htm>

King County Hazardous Waste Program

<http://www.metrokc.gov/hazwaste/house/>

King County Industrial Waste Program

<http://dnr.metrokc.gov/wlr/indwaste/index.htm>

King County Integrated Pesticide Management Program

<http://www.metrokc.gov/hazwaste/ipm/>

King County Sediment Management Program

<http://dnr.metrokc.gov/wlr/waterres/norfolk/norfolk.htm>

King County Biosolids Program

<http://dnr.metrokc.gov/WTB/biosolids/index.htm>

King County Water Reuse Program

<http://dnr.metrokc.gov/wtd/reuse/index.htm>

State of Waters

Cedar watershed

<http://dnr.metrokc.gov/wlr/watersheds/cedar-lkwa.htm>

Lake Washington

<http://dnr.metrokc.gov/wlr/waterres/lakes/biolake.htm>

<http://dnr.metrokc.gov/wlr/waterres/lakes/Wash.HTM>

Sammamish basin

<http://dnr.metrokc.gov/wlr/watersheds/samm.htm>

<http://dnr.metrokc.gov/wlr/waterres/lakes/SAMM.htm>

Lake Union

<http://dnr.metrokc.gov/wlr/waterres/lakes/UNION.HTM>

Green watershed

<http://dnr.metrokc.gov/wlr/watersheds/green.htm>

Puget Sound watershed

<http://dnr.metrokc.gov/wlr/watersheds/puget.htm>

King County salmon recovery activities

<http://dnr.metrokc.gov/topics/salmon/SALtopic.htm>

<http://dnr.metrokc.gov/Wrias/9/index.htm>

<http://dnr.metrokc.gov/Wrias/8/index.htm>